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NOUVELLE SÉRIE

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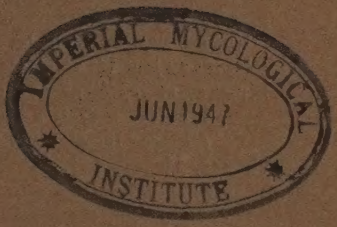

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MATHEMATICS

ON AN INTEGRAL ANALOGUE OF MACLAURIN SERIES

By V. LEVIN

(Communicated by A. N. Kolmogoroff, Member of the Academy, 20.II.1943)

Consider a power series $c_0+c_1x+c_2x^2+\ldots=\sum_{n=0}^{\infty}c_nx^n=f(x)$ with a radius of convergence $R>0$. The sequence of coefficients $\{c_n\}$ is to be replaced by a continuous function $\varphi(n)$, assuming for integral n the values c_n in such a way that the integral

$$\int_{n=0}^{\infty}\varphi(n)x^n dn;\ x>0,$$

should have sense and stand in a more or less comprehensive relation to $f(x)$. Since $c_n=\frac{f^{(n)}(0)}{n!}$, it is natural to put $\varphi(n)=\frac{f^{(n)}(0)}{\Gamma(n+1)}$, where $f^{(n)}(0)$ denotes a generalization of the conception of derivative to a non-integral order. Following Riemann and Liouville, we put

$$D^{\alpha}f(u)=\frac{1}{\Gamma(1-\alpha)}\int_{t=-\infty}^{u}(u-t)^{-\alpha}f'(t)\,dt=\frac{1}{\Gamma(1-\alpha)}\int_{v=0}^{\infty}\varphi^{-\alpha}f'(u-\varphi)\,d\varphi$$

where $0<\alpha<1$ and D denotes the operator of differentiation; and define the derivative of an arbitrary non-integral order $k+\alpha$, $k=0, 1, 2, \ldots$, by the $D^{k+\alpha}f(u)=\frac{d^k}{du^k}D^{\alpha}f(u)$. Thus

$$D^{k+\alpha}f(u)=\frac{1}{\Gamma(1-\alpha)}\frac{d^k}{du^k}\int_{v=0}^{\infty}\varphi^{-\alpha}f'(u-d)\,d\varphi. \tag{1}$$

We shall consider functions $f(z)$ regular in the domain Ω_R consisting of the half-strip $x=\mathrm{Re}\,z\leqslant 0, |\mathrm{Im}\,z|<R$ and the half-circle $x\geqslant 0, |z|<R\,(R>0)$. We subject, moreover, $f(z)$ to the condition that in the domain $\Omega_{R'}$ where $0<R'<R$, $|f(z)|<M=M(R')$. Then each of the integrals

$$\int_{v=0}^{\infty}\varphi^{-\alpha}f^{(k+1)}(u-\varphi)\,d\varphi$$

is uniformly convergent with respect to $u, -\infty<u\leqslant 0$, for every fixed $\alpha, 0<\alpha<1$, and (1) may be rewritten in the form

$$D^{k+\alpha}f(u)=\frac{1}{\Gamma(1-\alpha)}\int_{v=0}^{\infty}\varphi^{-\alpha}f^{(k+1)}(u-\varphi)\,d\varphi. \tag{2}$$

We note that under the conditions assumed, $\lim_{\alpha\to 0}D^{k+\alpha}f(u)=f^{(k)}(u)$ and

$\lim_{\alpha \to 1} D^{k+\alpha} f(y) = f^{(k+1)}(u)$. The continual analogue of the MacLaurin series

$$S_f(x) = \sum_{n=0}^{\infty} \frac{D^n f(0)}{n!} x^n = f(x), \quad -R < x < R,$$

is now given by the expression

$$I_f(x) = \int_{n=0}^{\infty} \frac{D^n f(0)}{\Gamma(n+1)} x^n dn, \quad 0 < x < R, \tag{3}$$

whereby between $I_f(x)$ and $f(x)$ exists the relation

$$I_f(x) = f(x) - \int_{y=-\infty}^{+\infty} \frac{f(-xe^y)}{\pi^2 + y^2} dy, \quad 0 < x < R.$$

Let us state some special cases of the deduced formula, namely, the integral analogues of MacLaurin series of some elementary functions.

Putting $f(x) = e^x$, we find

$$\int_{n=0}^{\infty} \frac{x^n}{\Gamma(n+1)} dn = e^x - \int_{y=-\infty}^{+\infty} \frac{e^{-xe^y}}{\pi^2 + y^2} dy, \quad 0 < x < \infty.$$

This formula belongs to S. Ramanujan.

Putting $f(x) = \cos x$ and $f(x) = \sin x$, we find correspondingly

$$\int_{n=0}^{\infty} \frac{\cos \frac{n\pi}{2}}{\Gamma(n+1)} x^n dn = \cos x - \int_{y=-\infty}^{+\infty} \frac{\cos(xe^y)}{\pi^2 + y^2} dy, \quad 0 < x < \infty,$$

$$\int_{n=0}^{\infty} \frac{\sin \frac{n\pi}{2}}{\Gamma(n+1)} x^n dn = \sin x + \int_{y=-\infty}^{+\infty} \frac{\sin(xe^y)}{\pi^2 + y^2} dy, \quad 0 < x < \infty.$$

Putting, further, $f(x) = (1-x)^{-\lambda}$, $\lambda > 0$, we find

$$\frac{1}{\Gamma(\lambda)} \int_{n=0}^{\infty} \frac{\Gamma(n+\lambda)}{\Gamma(n+1)} x^n dn = (1-x)^{-\lambda} - \int_{y=-\infty}^{+\infty} \frac{dy}{(\pi^2 + y^2)(1 + xe^y)^{\lambda}}, \quad 0 < x < 1,$$

whence, for $\lambda = m$, $m = 1, 2, 3, \ldots$, follows

$$\int_{y=-\infty}^{+\infty} \frac{dy}{(\pi^2 + y^2)(1 + xe^y)^m} = \frac{1}{(1-x)^m} - \frac{P_m(0)}{\ln \frac{1}{x}} - \frac{P'_m(0)}{\ln^2 \frac{1}{x}} - \ldots - \frac{P_m^{(m-1)}(0)}{\ln^m \frac{1}{x}}, \quad 0 < x < 1,$$

where $P_m(n) = \frac{1}{(m-1)!}(n+1)\ldots(n+m-1)$.

If we put $f(x) = \frac{\pi}{2} + \operatorname{arctg} x$, we find

$$\int_{n=0}^{\infty} \frac{\sin \frac{n\pi}{2}}{n} x^n dn = \operatorname{arctg} x + \int_{y=-\infty}^{+\infty} \frac{\operatorname{arctg}(xe^y)}{\pi^2 + y^2} dy, \quad 0 < x < 1.$$

Putting, finally, $f(x) = \frac{1}{1+x^2}$, we obtain similarly

$$\int_{y=-\infty}^{+\infty} \frac{dy}{(\pi^2 + y^2)(1 + x^2 e^{2y})} = \frac{1}{1+x^2} - \frac{4 \ln \frac{1}{x}}{4 \ln^2 \frac{1}{x} + \pi^2}, \quad 0 < x < 1.$$

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MATHÉMATIQUES

SUR LE CRITÈRE DE DINI DANS LA THÉORIE D'INTERPOLATION TRIGONOMÉTRIQUE

Par I. P. NATANSON

(Présenté par A. N. Kolmogoroff, de l'Académie, le 30.VIII.1943)

§ 1. Soit que le polynôme trigonométrique

$$T_n(x) = A + \sum_{k=0}^{n} (a_k \cos kx + b_k \sin kx) \tag{1}$$

coïncide avec une fonction $f(x)$ dans les points $x_k^{(n)} = \frac{2\pi}{2n+1} k \; (k = 0, 1, \ldots, 2n)$

La plupart des critères de convergence de $T_n(x)$ vers $f(x)$ ressemble beaucoup à ceux de convergence des séries de Fourier. Dans cette Note je vais donner un critère analogue à celui de Dini:

$$\int_0^{2\pi} \left| \frac{f(x) - f(x_0)}{x - x_0} \right| dx < +\infty. \tag{2}$$

Théorème. *Soit donnée une fonction $f(x)$ intégrable (R) dans le segment $[0, 2\pi]$ et soit $0 < x_0 < 2\pi$. S'il existe une fonction $\Phi(x)$ croissante dans le segment $[0, x_0]$, décroissante dans le segment $[x_0, 2\pi]$ et telle que*

$$\left| \frac{f(x) - f(x_0)}{x - x_0} \right| < \Phi(x), \tag{3}$$

$$\int_0^{2\pi} \Phi(x)\, dx < +\infty, \tag{4}$$

alors

$$\lim_{n \to \infty} T_n(x_0) = f(x_0). \tag{5}$$

En particulier, cette relation a lieu, si

$$|f(x) - f(x_0)| \leqslant K |x - x_0|^{\alpha} \qquad (\alpha > 0)$$

où, plus généralement, si*

$$|f(x) - f(x_0)| \leqslant \frac{K}{\ln \frac{1}{|x - x_0|} \cdot \ln_2 \frac{1}{|x - x_0|} \cdots \ln_m \frac{1}{|x - x_0|} \cdot \left(\ln_{m+1} \frac{1}{|x - x_0|} \right)^{1+\alpha}} \qquad (\alpha > 0)$$

Les conditions de notre théorème sont plus restrictives que la condition (2).

* Comme d'habitude, $\ln_1 x = \ln x$, $\ln_{m+1} x = \ln (\ln_m x)$.

Je montre que le critère (2) n'est pas suffisant pour la relation (5), même si nous nous bornons aux fonctions continues.

§ 2. Indiquons les lignes principales de la démonstration de notre théorème. Comme on sait

$$T_n(x_0)=\frac{1}{2n+1}\sum_{k=0}^{2n} f(x_k^{(n)})\frac{\sin\frac{2n+1}{2}(x_k^{(n)}-x_0)}{\sin\frac{x_k^{(n)}-x_0}{2}}.$$

Alors

$$T_n(x)-f(x_0)=\frac{1}{2n+1}\sum_{k=0}^{2n}\{f(x_k^{(n)})-f(x_0)\}\frac{\sin\frac{2n+1}{2}(x_k^{(n)}-x_0)}{\sin\frac{x_k^{(n)}-x_0}{2}}.$$

Soit* $x_m^{(n)}<x_0<x_{m+1}^{(n)}$. Nous pouvons examiner seulement la somme $\sum_0^m$, puisque la somme $\sum_{m+1}^{2n}$ est tout-à-fait analogue.

Prenons $\varepsilon>0$ et choisissons $\delta>0$ tel que

$$\int_{x_0-\delta}^{x_0}\Phi(x)\,dx<\varepsilon \tag{6}$$

et tel que l'inégalité $|x-x_0|<\delta$ entraîne l'inégalité

$$|f(x)-f(x_0)|<\varepsilon. \tag{7}$$

[En vertu de (3) et (4), notre fonction $f(x)$ est continue dans le point x_0].

Soit $x_{p-1}^{(n)}\leqslant x_0-\delta<x_p^{(n)}$. On peut démontrer que

$$\lim_{n\to\infty}\frac{1}{2n+1}\sum_{k=0}^{p-1}\{f(x_k^{(n)})-f(x_0)\}\frac{\sin\frac{2n+1}{2}(x_k^{(n)}-x_0)}{\sin\frac{x_k^{(n)}-x_0}{2}}=0.$$

Or, la somme

$$r_n=\frac{1}{2n+1}\sum_{k=p}^{m}\{f(x_k^{(n)})-f(x_0)\}\frac{\sin\frac{2n+1}{2}(x_k^{(n)}-x_0)}{\sin\frac{x_k^{(n)}-x_0}{2}}$$

ne surpasse pas la quantité

$$\frac{\pi}{2n+1}\sum_{k=p}^{m-1}\left|\frac{f(x_k^{(n)})-f(x_0)}{x_k^{(n)}-x_0}\right|+|f(x_m^{(n)})-f(x_0)|,$$

---

* Si pour quelques valeurs de n nous avons $x_k^{(n)}=x_0$, alors $T_n(x_0)=f(x_0)$ et nous pouvons les exclure de la considération.

d'où

$$|r_n| < \frac{1}{2} \sum_{k=p}^{m-1} \Phi(x_k^{(n)})(x_{k+1}^{(n)} - x_k^{(n)}) + \varepsilon$$

et a fortiori

$$r_n| < \frac{1}{2} \int_{x_0-\delta}^{x_0} \Phi(x)\,dx + \varepsilon < \frac{3}{2}\varepsilon, \text{ c. q. f. d.}$$

§ 3. Passons à l'exemple, montrant l'insuffisance du critère (2).

Soient $n > 8$ un nombre naturel, σ_n le plus grand nombre impair ne surpassant pas $\sqrt{n}$, $K_n = \{1, 3, \ldots \sigma_n\}$ et

$$\lambda_n = \frac{(2n+1)\sqrt{\ln \sigma_n}}{\sum_{i \in K_n} \frac{1}{\sin\left(\frac{2i-1}{2n+1} \cdot \frac{\pi}{2}\right)}},$$

Choisissons un nombre positif δ_n tellement petit que $x_{n+1}^{(n)} - \delta_n > \pi$, les intervalles $(x_{n+i}^{(n)} - \delta_n,\ x_{n+i}^{(n)} + \delta_n)$ $(i = 1, 3, \ldots, \sigma_n)$ ne contiennent pas les noeuds $x_{n+2k}^{(n)}$, et enfin,

$$\int_{x_{n+i}^{(n)} - \delta_n}^{x_{n+i}^{(n)} + \delta_n} \frac{dx}{x - \pi} < \frac{1}{2^n \lambda_n \sigma_n} \qquad (i = 1, 3, \ldots, \sigma_n).$$

Définissons maintenant la fonction $\varphi_n(x)$ de la manière suivante:

$$\varphi_n(x_{n+1}^{(n)}) = \varphi_n(x_{n+3}^{(n)}) = \ldots = \varphi_n(x_{n+\sigma_n}^{(n)}) = \lambda_n,$$

$$\varphi_n(x_{n+i}^{(n)} - \delta_n) = \varphi_n(x_{n+i}^{(n)} + \delta_n) = 0 \qquad (i = 1, 3, \ldots, \sigma_n)$$

$\varphi_n(x)$ est une fonction linéaire dans chacun des segments

$$[x_{n+i}^{(n)} - \delta_n, x_{n+i}^{(n)}] \text{ et } [x_{n+i}^{(n)}, x_{n+i}^{(n)} + \delta_n] \quad (i = 1, 3 \ldots, \sigma_n) \text{ et } \varphi_n(x) = 0$$

dans tous les autres points de $[0, 2\pi]$.

Cette fonction est continue, non-négative et telle que

$$\int_{\pi}^{2\pi} \frac{\varphi_n(x)}{x - \pi}\,dx < \frac{1}{2^n}. \tag{8}$$

En outre $\varphi_n(\pi) = 0$ et il existe $\varphi_n'(\pi) = 0$.

Si le polynôme d'interpolation, correspondant à la fonction $f(x)$, nous désignons par $T_n[f; x]$, alors

$$T_n[\varphi_n; \pi] = \sqrt{\ln \sigma_n}. \tag{9}$$

Après tout cela, nous déterminerons la suite $n_1 = 9 < n_2 < n_3 < \ldots$ en procédant, par récurrence, de la manière suivante: supposons que les nombres $n_1, \ldots, n_{k-1}$ sont déjà définis, et soit n_k la plus petite des valeurs de n pour lesquelles on a

$$x_{n+\sigma_n}^{(n)} + \delta_n < x_{n_{k-1}}^{(n_{k-1})} - \delta_{n_{k-1}}$$

$$|T_n[\varphi_{n_1} + \ldots + \varphi_{n_{k-1}}; \pi]| < 1. \tag{10}$$

Ceci étant, posons

$$f(x) = \sum_{k=1}^{\infty} \varphi_{n_k}(x).$$

Il est aisé de voir que cette série converge uniformément, parce que λ_n tend vers zéro quand n croît indéfiniment].

En vertu de (8) nous avons

$$\int_0^{2\pi} \left| \frac{f(x)-f(\pi)}{x-\pi} \right| dx < 1.$$

D'autre part

$$T_{n_k}[f, \pi] = T_{n_k}[\varphi_{n_1} + \ldots + \varphi_{n_{k-1}}; \pi] + T_{n_k}[\varphi_{n_k}; \pi] + T_{n_k}[\varphi_{n_{k+1}} + \varphi_{n_{k+2}} + \ldots; \pi].$$

Or; $\varphi_{n_k+s}(x_i^{(n_k)}) = 0$, d'où

$$T_{n_k}[\varphi_{n_{k+1}} + \varphi_{n_{k+2}} + \ldots; \pi] = 0$$

et, en vertu de (9) et (10)

$$T_{n_k}[f; \pi] > \sqrt{\ln \sigma_{n_k}} - 1.$$

Par conséquence

$$\overline{\lim_{n\to\infty}} T_n[f; \pi] = +\infty.$$

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TECHNICAL PHYSICS

RESOLUTION OF LARGE OBJECTS IN CONTACT BY AN OPTICAL SYSTEM

By D. J. HALPERN

(Communicated by S. I. Wawilow, Member of the Academy, 30.VIII.1943)

What is usually meant by the resolving power of an optical system is a quantity inversely proportional to the least distance between two luminous points of equal brightness when they are still seen to be separated by a barely visible dark interval.

The condition generally recognized to be sufficient for a distinct separation of two such points is that the quantity

$$\frac{I_{max} - I_{min}}{I_{max}} = \frac{\Delta I}{I_{max}}$$

hould not be less than a certain constant quantity K. Here I_{min} is the mean minimum value of illumination whose position on the distribution-of-illumination curve for the image of the two luminous points is between the two maximum values of illumination.

The quantity K varies from 0.05 to 0.25 according to the visual properties of the individual observer. In other words, the resolving power, as a quantity, is commonly understood to be referred to the particular case of a test-object in the form of two points; or, which nearly amounts to the same, in the form of two thin parallel lines.

It will be obvious, however, that this case cannot possibly cover the variety of objects one has to deal with in practice.

So let us extend the notion of resolving power over objects of arbitrary form. To begin with we shall define the distance between objects of arbitrary convex outlines.

For the distance between two such objects we take the least interval between some two points of their respective contours. It may easily be seen that the tangents at these points are parallel to each other (Fig. 1). For the objects bounded by contours of the shape represented in Fig. 2, the distance is measured by the diameter of the largest circumference comprised within the dark space.

Let us now define the magnitude of the resolving power to vary inversely as the distance between the objects, at which the dark interval is barely noticeable.

The condition for the visibility of this dark interval is again supposed by us to be expressed by the inequality

$$\frac{I_{max} - I_{min}}{I_{max}} > K$$

where K, I_{max} and I_{min} have the same meaning as before.

Thus, the problem of resolving power is converted into that of the possibility to recognize a dark figure against a light background.

It will be shown now that there are two classes of test-objects.

In the f i r s t belong those having an infinitely small breadth in the direction normal to the contour at the site of possible contact, while the objects of the s e c o n d class have a sufficiently large breadth in the same direction (Figs. 3 and 4). For the latter the value of the resolving power is much greater than for the former.

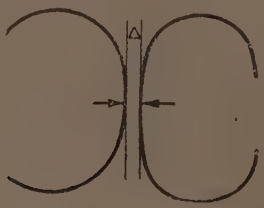

Fig. 1

Fig. 2

Hereafter we shall make use of the following statement which is all but obvious: if some black figure (S_1) is recognizable against a light background of sufficient extension, the more so will be any other figure (S_2) containing the former.

In the case of an infinitely wide background this statement admits of a

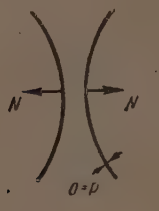

Fig. 3

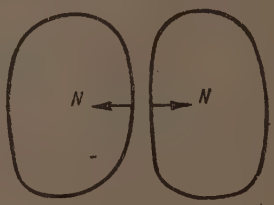

Fig. 4

rigorous proof. Supposing, in fact, illumination to equal 1 at infinity, we shall have for the maximum illumination a value $\geqslant 1$.

The minimum value is

$$Y_{S_1\min} = \iint\limits_{S_1} \frac{I_1^2\left(\sqrt{(x_{\min}-x)^2+(y_{\min}-y)^2}\right)}{\left(\sqrt{(x_{\min}-x)^2+(y_{\min}-y)^2}\right)^2}\,dxdy\,.$$

Now, turning to the figure S_2; its minimum value of illumination is at any rate less than $Y_{S_1\min}$

$$Y_{S_2\min} < Y = Y_{S_1\min} - \iint\limits_{S_2-S_1} \frac{I_1^2\left(\sqrt{(x_{\min}-x)^2+(y_{\min}-y)^2}\right)}{\left(\sqrt{(x_{\min}-x)^2+(y_{\min}-y)^2}\right)^2}\,dxdy$$

where the last integral is a positive quantity. Thus

$$A = Y_{S_2\min} \geqslant 1 - Y_{S_1\min},\ Y_{\max} \geqslant 1.$$

The last inequality proves our statement.

We have assumed the light background to be of infinitely wide extension with no other aim than to make the quantity $Y_{\max}$ independent of the dimensions and configuration of the dark test-object. It is obvious, however, that

Y_{max} is to all intents and purposes a constant quantity whenever the larger of the two figures is surrounded by a light border as wide as several diameters of the Airy disk.

After this remark it may be asserted that for two test-objects of the second class to be resolvable, the distance between them should be greater than or equal to the breadth of the dark band or the diameter of the dark circle recognizable against a light background.

It remains therefore to establish the least breadth of the dark band or the least diameter of the circle when they are yet noticeable on a light background.

The distribution of illumination in the direction perpendicular to the long edge of the slit may easily be shown to be expressed by the following formula

$$Y = \left[\int_a^b \frac{I_1^2(x_1+x)}{(x_1+x)^2}\,dx + \int_a^b \frac{I_1^2(x_1-x)}{(x_1-x)^2}\,dx \right] \frac{3}{8}\pi^*.$$

Here I_1 is a Bessel function of the first order; x_1, the coordinate of the point at which the illumination is determined; a and b, the coordinates determining the position of the edges of the light background. The factor $\frac{3}{8}\pi$ so normalizes the values of Y that for $x_1 \to \infty$ we have $Y = 1$. x, x_1, a and b are measured by special optical units which are connected with the ordinary units of length by the relation $x = \frac{2\pi}{\lambda} \sin \sigma_0 z$, where λ is wave-length; σ_0, the aperture angle in the image space; z, distance.

The computation of the integrals presents no difficulties. For the middle of the dark band, where illumination is a minimum, we put $x = 0$ to obtain:

$$Y_{min} = \frac{3}{8}\pi \int_a^b \frac{I_1^2(x)}{x^2}\,dx = \frac{3}{8}\pi \left\{ \left(b \left[I_1^2(b) + I_0^2(b) + \frac{I_1^2(b) - I_2(b)\,I_0(b)}{3} \right] - \right.\right.$$

$$\left. - I_0(b)\,I_1(b) - \frac{I_2(b)\,I_1(b)}{3} \right) - \left(a \left[I_1^2(a) + I_0^2(b) + \frac{I_1^2(a) - I_2(a)\,I_0(a)}{3} \right] - \right.$$

$$\left.\left. - I_0(a)\,I_1(a) - \frac{I_2(a)\,I_1(a)}{3} \right) \right\}.$$

Table 1

Illumination in the Middle of a Dark Slit as Wide as $2a$ Optical Units

a	Y_{min}	K
0.2	0.99	0.01
0.5	0.74	0.26
1.0	0.46	0.54
2.0	0.13	0.87
3.0	0.10	0.90
4.0	0.02	0.98

Table 2

Illumination in the Centre of a Dark Circle of Radius ρ_1 for $\rho_2 = \infty$

ρ_1	Y_{min}	K
0.2	0.99	0.01
0.5	0.93	0.07
1.0	0.78	0.22
2.0	0.38	0.62
3.0	0.18	0.82
4.0	0.16	0.84

In Table 1 are listed the data of

$$K = \frac{Y_{max} - Y_{min}}{Y_{max}} = 1 - Y_{min} \quad (b \to \infty).$$

* Strictly speaking, this formula corresponds to the distribution of illumination along a segment of a light straight line with a $2a$ wide break.

In the centre of the dark circle the illumination is determined by the relation

$$Y_{\min} = 2 \int_{\rho_2}^{\rho_1} \frac{I_1^2(\rho)}{\rho} d\rho = -[I_0^2(\rho_2) - I_0^2(\rho_1)] + [I_1^2(\rho_2) - I_1^2(\rho_1)]$$

and the value of K is easily computed (Table 2).

On examining these tables we find that two second class objects are still seen to be separated when the distance between them is 3 to 4 times as small as the resolving power determined, according to its usual definition, from the formula

$$z = \frac{0.61\,\lambda}{\sin \varepsilon} \quad (x = 3.83).$$

This considerable difference in the value of the resolving power as calculated for the test-objects of the first and of the second class has a simple physical sense. In the direction perpendicular to the screen the distribution of illumination at the edge of the screen is determined by the formula

$$Y = \frac{3}{8}\pi \int_0^{\infty} \frac{I_1^2(x_1 - x)}{(x_1 - x)^2}\, dx; \quad Y_{x \to \infty} = 1.$$

At the edge of the screen ($x_1 = 0$) the illumination $Y = \frac{1}{2}$ takes no extremal value.

When two such screens are shifted together until the distance between them is $2\Delta x$, the illumination in the middle of the interval becomes $Y_{\min} = 1 + a\Delta x + b\Delta x^2 \ldots$ (a Taylor series).

Besides, we have $Y_{\max} > 1$ and $K_1 = \frac{I_{\max} - I_{\min}}{I_{\max}} = \Delta x\,(a + b\Delta x^2 + \ldots)$.

For an infinitely narrow band the illumination in its geometrical image is a maximum and likewise equals 1, so that in the Taylor expansion of Y the term with Δx is absent.

Shifting two such lines toward each other in the above manner, we obtain

$$Y_{\min} = 2 + 2a_1\Delta x^2 + 2b_1\Delta x^3 + \ldots$$

$$Y_{\max} = 1 + (1 + 4a_1\Delta x^2 + 8b_1\Delta x^3 + \ldots)$$

and the value of K is

$$K_2 = 2\Delta x^2 (a_1 \ldots).$$

Comparing the formulae for K_1 and K_2 and putting $K_1 = K_2$, we get $\Delta x = p\Delta x_1^2$, i. e. the resolvable distance for the test-objects of the second class is a quantity of the second order of smallness as compared to that for the test-objects of the first class. Thus, the reason for the difference in the resolving power with the objects of the first class and the second is that no extreme values are assumed by the illumination at the edge of a sufficiently extensive test-object, whereas in the case of infinitely narrow test-objects the illumination is just a maximum at the place of their possible coincidence.

There is also another essential difference to be noted in comparing the resolution of the test-objects belonging to the first class and of those belonging to the second.

When two test-objects of the first class are approaching each other, they eventually come into such a position that the central minimum becomes a maximum. This will never occur with the test-objects of the second class.

Finally, the computation of Y for the centre of the image of a black circle of radius ρ is possible even if the spherical aberration of the system is not equal to zero.

Let the distribution of illumination in the image of a point be $Y_0 = F(r)$. Then the illumination in the centre of a dark circle on a light background extended to infinity is

$$Y(\rho) = \int_0^{2\pi} \int_0^{\infty} F(r)\, r dr d\varphi - \int_0^{2\pi} \int_0^{\rho} F(r)\, r dr d\varphi .$$

Now the first integral represents the illumination at the points of an infinite plane. The value of the integral is put at unity [the condition for normalization of $F(r)$].

On the other hand, the energy within the circle of radius ρ drawn about the image of an individual point is

$$E(\rho) = \int_0^{2\pi} \int_0^{\rho} F(r)\, r dr d\varphi$$

[E is so normalized that $E(\infty) = 1$].

By comparing the values of $Y(0)$ and $E(\rho)$ we obtain

$$Y(0) = [1 - E(\rho)]\, a,$$

where a is a factor numerically equal to 1, and necessary for sticking to adopted dimensions.

Some remarks on the resolution of test-objects of specified shape are to be found in Rayleigh's papers [1]. But it does not appear that any general statement similar to that discussed here was ever made before.

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TECHNICAL PHYSICS

PHOTOELECTRIC METHOD FOR ESTIMATION OF ZINC CONTENT IN BRASS BY SPECTRUM ANALYSIS

By N. M. HOPSTEIN, F. Z. PEDOS, V. K. PROKOFIEV and N. S. SVENTITSKY

(Communicated by S. I. Wawilow, Member of the Academy, 30.VIII.1943)

The working out of methods for direct photometry of spectral lines stands prominently among the problems facing the spectral analyst. For a long time the possibility of making rapid and objective quantitative estimations by means of a photocell has been attracting the attention of investigators.

As early as in 1930 Lundegardh (1) was successful in determining the content of calcium in its solutions photoelectrically. Thanheiser and Heyes (2) carried out the analysis of Cr and Mn in steels by direct photometric measurement, using a flame or a spark as a source of light. The photoelectric currents due to the radiation of the individual spectral lines separated by a monochromator were measured

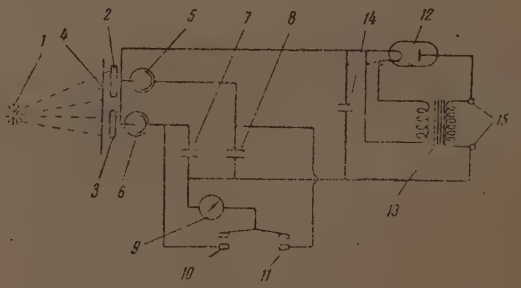

Fig. 1

by a sensitive electrometer. Schuknecht (3) restricted his attack at the problem to the estimation of potassium in solutions, which he successfully carried out. The set-up developed for this purpose is remarkably simple and inexpensive. The solution to be tested was introduced into a flame which had a photocell placed near it with a filter transmitting light rays from the red lines of potassium. The photocell likewise possessed selectivity for red radiation.

Mention should also be made of the interesting suggestions by Kreuzer and Heyes (4) who proposed to send to the photocell rays from more than one spectral line.

The isolation of these rays is effected by the corresponding diaphragms placed in a simplified spectral apparatus. This results in a greater quantity of light energy falling upon the photocell. Duffendack and Morris (5) resorted to a photoelectric counter on the consideration of the greater expediency; while wor-

king with the usual light sources, such as the spark or arc; to measure the energy of the radiation for a certain interval of time; rather than its intensity.

When a condensed spark or an a. c. arc are used as a source of light, the photoelectric recording of spectral energy is hampered by the following two circumstances:

1) The energy falling on the photocell from a single spectral line being of insignificant magnitude, there arises the necessity of increasing as much as possible the relative aperture of the spectral apparatus employed, or else to have recourse to amplification schemes possessed of a high sensitivity to the electric influence of the light source.

2) Because of the unstable burning of the spark or arc, we are compelled to the integration of energy (exposure) over a certain interval of time.

What is described below is a photoelectric set-up of simple construction intended for quantitative estimations of zinc in brasses. Its relative aperture is increased by the separation of the requisite spectral regions with the aid of light filters. The integration of the radiation energy is effected through the accumulation of electric charges on condensers connected with the photocells.

Fig. 1 is a schematic representation of this apparatus. *1* is source of light; *2* and *3* are light filters; *4* is shutter; *7* and *8* are condensers charged by currents from photocells *5* and *6*; *9* is galvanometer; *12* is rectifying valve; *13* is transformer of valve; *14* is kenotrone condenser; *15*, terminals of 120 volt a. c.

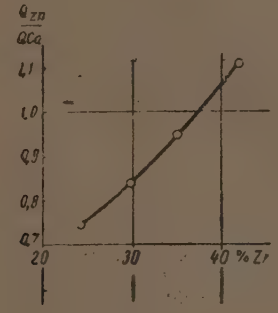

Fig. 2

The light source in determining the content of zinc in brass was an a. c. arc (6) placed 175 mm away from the photocells. While the sample tested served as the lower electrode of the arc, its upper electrode was a copper rod, 10 mm in diameter, with a blunt-pointed end. The width of the air gap, 1.5 mm. Arc current, 6 amp. Duration of preliminary annealing, 30 sec. Time of exposure, 1 min. With the aid of filter *2* the region containing the green lines of copper (5218, 5153 and 5 Å) is separated, while that containing the blue lines of zinc (4810, 4722 and 4680 Å) is separated by filter *3*. To be sure, there is in the spectrum part let through by filter *3* more than one faint line of copper, and their radiation is superimposed upon that of the zinc lines; but this is no serious handicap. We used antimony-caesium vacuum photocells with a sensitivity of 60 μA per lumen. The condensers *7* and *8* had a capacity of 0.5 μF each. The magnitide of the condenser charges was evaluated from the readings of a galvanometer switched-in by push-buttons *10* and *11* in alternation.

The calibration of the set-up was made with samples of known chemical composition. In Fig. 2 is shown a calibration graph for determining the content of zinc, based on the tabulated data. The ordinates give the ratios of condenser charges, and the abscissae; the content of zinc in brass. Every point of the graph is an average of 10 measurements.

No. of specimens	Content of zinc in %	Q_{Zn}/Q_{Cu}
121	41.9	1.11
11	35.0	0.95
7	29.7	0.84
5	24.2	0.75

The probable error of an estimation, as computed from a large number of replicate measurements (50 measurements in the case of sample 5), is 3.3 per cent. A duplicate estimation usually lasts 5 minutes. The technique of carrying on the measurements is very simple and can be easily mastered by a worker of no high qualification.

The method affords, thus, the possibility of testing binary copper-zinc alloys for the zinc content. It may as well be applied to other constituents of a non-ferrous alloy by selecting correspondingly the spectral lines and filters.

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GEOPHYSICS

INFLUENCE OF CLOUDS UPON THE MAGNITUDE OF SOLAR RADIATION AND OF RADIATION SCATTERED BY THE ATMOSPHERE

By N. N. KALITIN

(Communicated by A. A. Grigoriev, Member of the Academy, 19.VIII.1943)

In the case of a cloudless sky solar radiation creates at a given point of the globe a so-called solar climate which is determined by the latitude of a given point and by the transparency of the atmosphere. Those two factors and the magnitude of the solar constant being known, it is possible to calculate this climate. Such calculations of the solar climate for the whole globe have been made more than once. One of the recent works in this line belongs to Milankovich (1).

The presence of cloudiness, unconstant and various as it may be, strongly affects the solar climate. The variations it causes defy theoretical calculation and in order to find them out direct observations are necessary. Observations on the radiation regime carried on during many years at Slutzk, as well as the hourly records of cloudiness initiated there by E. E. Fedorov, gave a bulk of material the treatment of which made it possible to investigate the influence of clouds upon the inflow of solar and scattered radiation.

With a cloudless sky the inflow of radiation will be determined by the direct solar radiation and that scattered by the atmosphere. The effect of cloudiness will in the general case be to reduce the intensity of solar, and augment the scattered radiation.

As material for the present work the author made use of records of the intensity of solar radiation taken by means of an actinograph, and those of the scattered radiation, taken with the help of Yanishevsky's pyranograph, for a period from 1936 till 1940, as well as of hourly observations on the amount and shape of the clouds, made within the same period. Only those one-hour intervals were treated when the cloudiness belonging to the same classes attained 10 points. Within a period of five years, from April to September, only 843 such hour intervals happened to occur at various altitudes of the Sun.

Naturaly enough, the frequency of various classes of clouds was not the same; thus, out of the 843 cases observed, 200 fell to the share of *St*, and 65 to *As*. If the number of observations for a certain class of clouds was less than 65, they were omitted from the treatment. Therefore we give here data for the following classes only: cirrus (*Ci*); cirro-stratus (*Cs*); altitudinal cumulus (*Ac*); altitudinal-stratus (*As*); ragged-stratus (*Frst*); stratus-cumulus (*Sc*); stratus (*St*) and stratus-nimbus (*Ns*); when summing up, the two last classes have been unified into a single group (*St*).

The intensity of solar radiation I' as well as that of scattered radiation, i, given here is understood to hit a horizontal surface. The summing up of the two flows of radiation gives the so-called total radiation, $I' + i$. All the radiation magnitudes are given in calories and according to the European scale.

The magnitude of solar radiation intensity with a definite class of clouds and a definite altitude of the Sun was obtained from the readings of the actinograph

as a mean for one hour. When treating the material, the magnitude of solar radiation intensity thus found was referred to the mean Sun height for one hour. The magnitudes of the radiation scattered by the atmosphere have been obtained in the same way.

The results are given in Table 1. In order to analyse in more detail the influence of the cloudiness of a given class upon the magnitude of radiation, the material was treated graphically. A graph was plotted for every group of clouds; in this graph every measurement was represented by a point whose position was determined by the intensity of radiation and height of the Sun.

Fig. 1 shows the distribution of those points for 85 observations with *Ci* clouds. The solid curve represents the radiation magnitudes for a cloudless sky; the dotted curve, the smallest magnitudes for the densest clouds of a given class.

There were cases when a point expressing the magnitude of radiation for a covered sky did not only fit within the line of radiation for a cloudless sky, but even fell outside its limits. This should be explained in the following way. First, the

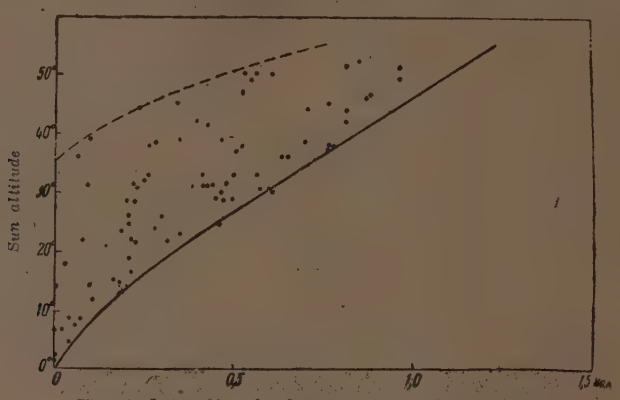

Fig. 1. Intensity of solar radiation with *Ci* clouds

curve plotted for an uncovered Sun has been plotted for an average atmosphere transparency. Therefore with very thin clouds covering the Sun, or with the Sun shining through a cloud in case of excessive atmosphere transparency, the solar radiation intensity may happen to exceed the initial magnitude. Secondly, all actinometrical instruments serving to measure the intensity of solar radiation, record not only that of the Sun itself, but also of the sky in its nearest vicinity. It may, however, occur that the Sun will not be covered or will be covered with very thin clouds, while bright clouds will be close by. In this case the measurements will give an exaggerated magnitude of radiation; work made in this direction has shown (2) that for some classes of clouds the overestimation may reach 6—7 per cent.

By averaging the position of the points, it is possible to obtain the mean magnitude of solar radiation intensity for the clouds of the class investigated, as dependent on the height of the Sun above the horizon. In the upper part of the table these mean magnitudes of I' are given for various classes of clouds. The table shows, e. g., that at a height of the Sun under 15° the radiation of the Sun is not let to pass by *Ci* clouds. The greater the altitude of the Sun, the larger is the amount of radiation I' passing through the clouds.

Clouds of the medium stage, to which *Ac* and *As* belong, become transparent at a Sun height of about 40°. In some separate cases the passage of radiation through the cloud of this class will, of course, be more dependent on the altitude of the Sun than with *Ci*, for an important part will belong here to the thickness of the cloud formations and to the distance between them. The greater the distance and

Table 1

Intensity of Solar Radiation I' at a Horizontal Surface, of Scattered Radiation i and Total Radiation $I'+i$ for Different Classes of Clouds and Sun Altitudes

Class of clouds \ Sun altitude	0°	2°.5	5°	7°.5	10°	15°	20°	25°	30°	40°	50°
					I'						
No clouds	0.00	0.03	0.06	0.09	0.13	0.22	0.33	0.46	0.59	0.84	1.10
Ci	0.00	0.00	0.00	0.00	0.00	0.04	0.11	0.21	0.32	0.60	0.90
Cs	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.09	0.18	0.42	0.70
Ac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.31
As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.10
Frst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05
Sc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
St	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					i						
No clouds	0.00	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.11	0.12
Ci	0.01	0.03	0.05	0.07	0.09	0.13	0.16	0.19	0.22	0.26	0.29
Cs	0.02	0.04	0.06	0.09	0.11	0.15	0.19	0.23	0.27	0.34	0.40
Ac	0.01	0.04	0.06	0.09	0.11	0.16	0.22	0.26	0.31	0.39	0.44
As	0.02	0.03	0.05	0.07	0.09	0.13	0.17	0.20	0.24	0.30	0.35
Frst	0.00	0.01	0.02	0.02	0.03	0.05	0.08	0.13	0.16	0.21	0.24
Sc	0.00	0.00	0.01	0.02	0.04	0.08	0.13	0.17	0.20	0.27	0.33
St	0.00	0.01	0.02	0.02	0.04	0.06	0.08	0.10	0.13	0.16	0.19
					$I'+i$						
No clouds	0.00	0.05	0.09	0.13	0.18	0.29	0.41	0.55	0.69	0.96	1.22
Ci	0.01	0.03	0.05	0.07	0.09	0.17	0.27	0.40	0.54	0.86	1.19
Cs	0.02	0.04	0.06	0.09	0.11	0.15	0.20	0.32	0.45	0.76	1.10
Ac	0.01	0.04	0.06	0.09	0.11	0.16	0.22	0.26	0.31	0.51	0.75
As	0.02	0.03	0.05	0.07	0.09	0.13	0.17	0.20	0.25	0.35	0.45
Frst	0.00	0.01	0.02	0.02	0.03	0.05	0.08	0.13	0.16	0.22	0.29
Sc	0.00	0.00	0.01	0.02	0.04	0.08	0.13	0.17	0.20	0.27	0.33
St	0.00	0.01	0.02	0.02	0.04	0.06	0.08	0.10	0.13	0.16	0.19

the smaller the thickness of the clouds; the smaller is the height of the Sun at which these clouds will let radiation pass through them (3).

With clouds of the lower stage; only *Frst* clouds let pass insignificant amounts

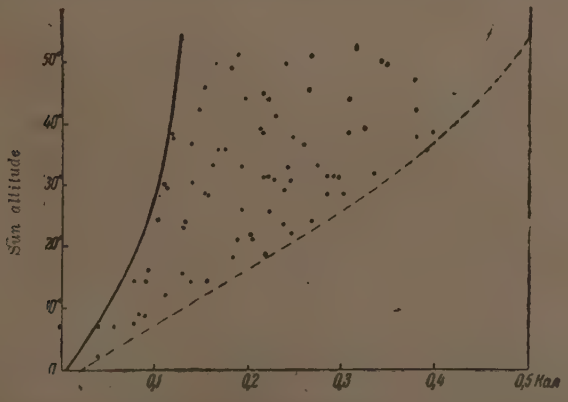

Fig. 2. Intensity of scattered radiation with *Ci* clouds

of radiation at a height of the Sun of about 50°; the other classes of this stage do not let pass any Sun radiation at all.

In the same way graphs were plotted for i; for every class of clouds; in this case the area over which the points were distributed; was bounded by the following curves: the curve of the magnitude of the scattered radiation of the atmosphere with a cloudless sky and a medium atmosphere transparency, and the curve passing through the points for the greatest radiation magnitudes measured. In Fig. 2 is shown the position of the points and of the bounding curves for *Ci* (the same 85 observations, as in Fig. 1).

As compared with the radiation of cloudless sky; the changes caused by clouds of various classes are the following.

The clouds of the upper stage, *Ci* and *Cs*, increase the radiation at any Sun altitude. From Table 2 it is seen that with *Ci* the radiation exceeds that of the cloudless sky on the average by 67 per cent for a Sun altitude of 5°, reaching 142 per cent for a Sun altitude of 50°.

The clouds of the medium stage, the most typical representative of which are *Ac*, increase the radiation from 100 per cent at a Sun height of 5°, to 267 per cent at a height of the Sun of 50°.

The clouds of the lower stage; for instance *St*, offer a different picture. Possessing a much greater mass and density than those of the upper and medium stages; at small Sun altitudes; instead of increasing the radiation, these clouds reduce it as compared to that of a cloudless sky, and it is not until the Sun rises to important altitudes that they begin to cause an increase of radiation. With *St* at a Sun height of 5°; the radiation is decreased by 33 per cent, at a height of 20° the radiation does not differ from that with a cloudless sky. At great altitudes the radiation begins to increase; though slightly; thus; with 50° it increases by 58 per cent.

Table 2

Increase in Intensity of Scattered Atmosphere Radiation with Clouds of Various Classes (in per cent)

Class of clouds	Sun altitude					
	5°	10°	20°	30°	40°	50°
Ci	67	80	100	120	133	142
Ac	100	120	175	210	225	267
Sc	—67	—20	63	100	125	175
St	—33	—20	0	30	38	58

For the *Frst* clouds the critical height also corresponds to 20°; below this Sun height the presence of clouds reduces the radiation, while at greater altitudes they go to increase it. The respective height for *Sc* is 12°.

Thus, the clouds do, on the one hand, reduce the magnitude of the intensity of the Sun radiation; on the other hand, they augment the scattered radiation, except for clouds of the lower stage and with small altitudes of the Sun. As a result, there is obtained the total effect of the action; $I'+i$; as shown in the bottom part of Table 1.

Summing up; the influence of cloudiness results on the average in a decrease of the inflow of total radiation as compared to cloudless sky. Table 3 illustrates the decrease in total radiation for the classes of clouds investigated and for Sun altitudes ranging between 5 and 50°, expressed in per cent to total radiation with uncovered sky.

From this table it may be seen that the ultimate effect upon the inflow of $I'+i$ is greatly dependent upon the shape of the clouds, and with classes of higher stages, on the altitude of the Sun over the horizon. For clouds of upper stages this relation is rather considerable ranging between 40 and 50 per cent with small heights and attaining 10 per cent for great ones (50°).

Table 3

Decrease in Intensity of Total Radiation with Cloudiness (in per cent)

Class of clouds	Sun altitude					
	5°	10°	20°	30°	40°	50°
Ci	—44	—50	—34	—22	—10	— 2
Cs	—33	—39	—51	—35	—20	—10
Ac	—33	—39	—46	—55	—46	—38
As	—44	—50	—59	—64	—63	—63
Frst	—78	—83	—80	—77	—77	—76
Sc	—89	—78	—68	—71	—72	—73
St	—78	—78	—80	—81	—83	—84

With clouds of the bottom stage the dependence of radiation intensity upon the height of the Sun is not manifest. Clouds of these classes reduce the inflow of radiation by about 80 per cent on the average.

It is necessary to investigate the effect of cloudiness at Sun altitudes greater than 50°; too. As it is obvious from Table 3, with clouds of the upper stage, the total effect will probably be to augment rather than to reduce the inflow of radiation. The rôle of the snow covering (albedo) is also to be studied; without directly affecting the intensity of the direct radiation of the Sun; it may considerably increase the scattered radiation of the atmosphere.

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CHEMISTRY

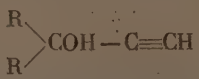
ELECTROLYTIC HYDROGENATION OF ACETYLENIC ALCOHOLS AND DIACETYLENIC GLYCOLS

By A. I. LEBEDEVA

(Communicated by A. E. Favorsky, Member of the Academy. 13.IX.1943)

Electrolytic hydrogenation of an alcohol of acetylenic series, viz. dimethylacetylenylcarbinol, has been developed by A. E. Favorsky, Member of the Academy, and myself in 1936 (1). The ethylenic alcohol — dimethylvinylcarbinol — obtained has been dehydrated to yield isoprene; used in the manufacture of synthetic rubber. We have demonstrated the following facts in that study and in the subsequent papers:

1) The catalytic effect of the material of the cathode and the structure of the given acetylenic alcohol have decisive importance in the catalytic hydrogenation of acetylenic alcohols. Thus; for instance, the hydrogenation of acetylenic alcohols of the type



where R is an aliphatic radical, is possible only at copper or silver cathodes, the acetylenic linkage under the conditions; developed by the authors; being hydrogenated strictly into ethylenic one.

2) The pre-treatment of the surface of the cathode; the so-called «history of the cathode». is one of the decisive factors. During the present investigation the advantage of silver cathodes over copper ones has been established. Silver cathodes are less susceptible to impurities; the velocities of hydrogenation at their surface are higher and the final product is purer. The cathodes coated with contact silver are particularly recommended (2).

3) The electrolytic hydrogenation in an alkaline electrolyte proceeds smoothly, whereas in an acid electrolyte a considerable number of side reactions is observed. Along with the primary product; namely dimethylvinylcarbinol; in the case of hydrogenation of dimethylacetylenylcarbinol in dilute sulphuric acid; isoprene; isobutenylcarbinol; dimethyltrimethylene glycol, linalool, terpinehydrate and some traces of farnesol have been isolated (3).

The data obtained were sufficient for the preparation of isoprene and synthetic rubber from dimethylacetylenylcarbinol. In the studies fulfilled the experiments were carried out in such a way that the cathodic space was separated from the anodic one by a semi-permeable membrane, thus considerably complicating the scheme of the industrial plant for electrohydrogenation. In the present paper we have shown that by applying nickel or nickel-plated anode with sufficiently high anodic current density (1.5 to 4 amperes per dm^2), the hydrogenation may be

carried out without separation of anodic and cathodic spaces the final product containing from 80 to 90 per cent of the ethylenic alcohol and but some traces of by-products. Quite different results have been obtained by dehydrogenation at low anodic densities (0.1 ampere per dm^2). In this case a deposit of white crystals in the shape of beautiful needles has been formed on the cathode. The yield of the crystals was 20 to 30 per cent in terms of the dimethylacetylenylcarbinol introduced. After crystallization from benzene the crystals melted at 131 to 132°. Determination of molecular weight by ebullioscopic method in ethyl ether gave $M = 162$; calculated for $C_{10}H_{14}O_2$ $M = 166$. Thus; it has been shown that at low current densities a peculiar process of synthesis of tetramethylhexadiindiol or 2.7-dimethyl-3.5-octadiin-2.7-diol from dimethylacetylenylcarbinol takes place. The mixed melting point of our tetramethylhexadiindiol with that obtained by the method of Zalkind and Ayzikovitch (4) showed no depression. When methylethylacetylenylcarbinol was hydrogenated under the same conditions; diacetylenic glycol—3.8-dimethyl-4.6-decadiin-3.8-diol—was obtained which after crystallization from benzene had m. p. 76 to 77°; and after crystallization from water melted at 89 to 90°; in total agreement with the data available in the literature. I was able definitely to establish the formation of copper derivatives of acetylenic alcohols dissolved in the alkaline electrolyte when the electrolysis was carried out on a copper electrode or in the presence of copper salts. The copper derivative of dimethylacetylenylcarbinol has been isolated from the solution by saturating the latter with carbon dioxide; and analysed. The following data have been obtained:

C—40.55%; H—5.07%; Cu—43.18%
C—40.60%; H—5.11%; Cu—43.17%

Calcd. for C_5H_7OCu:
C—40.93%; H—5.30%;
Cu—43.36%.

The following results have been obtained by analysis of the copper derivative of methylethylacetylenylcarbinol:

C—44.50%; H—5.79%; Cu—39.44%
C—44.62%; H—5.83%; Cu—39.42%

Calcd. for $C_6H_{11}OCu$;
C—44.83%; H—5.61%:
Cu—39.61%.

When the copper derivative of dimethylacetylenylcarbinol was oxidized according to Favorsky and Morev (5), tetramethylhexadiindiol was obtained. It cannot yet be regarded as finally ascertained whether or not the copper compound is an intermediate product in the formation of diacetylenic glycols during the hydrogenation process.

Even during the first studies on the electrolytic hydrogenation of acetylenic alcohols we have noticed in the electrolyte the presence of a very pleasant; though weak odour suggestive of geraniol. When hydrogenating dimethylacetylenylcarbinol at low current densities without separation of the electrodes; we had succeeded in isolating a few drops of a fragrant oil. Assuming that this fragrant product might be formed during hydrogenation of tetramethylhexadiindiol obtained in turn from dimethylacetylenylcarbinol by hydrogenation; we have hydrogenated under the same conditions of current density (0.1 ampere per dm^2) some diacetylenic glycol prepared beforehand. The resulting product was a light-yellow oil with a pleasant odour. By fractionating the oil *in vacuo* the following fractions have been obtained:

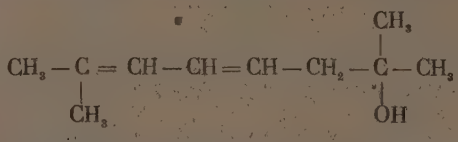
	Boiling point	Physical state	Yield, %
I	30— 90° (8 mm)	liquid	2—3
II	90—100° (6 »)	»	30—40
III	100—122° (6 »)	crystalline	15—18
IV	Residue	»	10

Fraction I was not investigated in detail. The crystals of fraction III after

repeated recrystallization melted at 85 to 86°. The Liebig's combustion analysis results are in best agreement with the formula $C_{10}H_{18}O_2$; no further investigation of this fraction has yet been carried out. About 10 g of almost colourless oil, boiling at 73 to 75° at 2 mm, have been separated from fraction II by repeated fractionation *in vacuo*. The following results have been obtained by the Liebig's combustion analysis:

C—77.98%; H—11.54%	Calcd. for $C_{10}H_{18}O$:
C—77.57%; H—11.75%	C—77.93%; H—11.69%

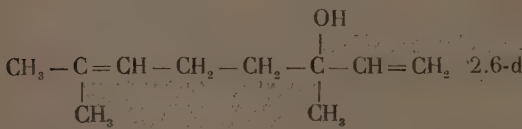
Determination of molecular weight in benzol by cryoscopic method gave the mean value $M=153.6$; calculated for $C_{10}H_{18}O$ $M=154$. The presence of a single hydroxyl group (92.6 per cent of hydroxyl) has been demonstrated with methylmagnesium iodide by the Chugaev-Zerevitinov's method. On catalytic hydrogenation with platinum oxide 100. 8 per cent of hydrogen added if computed for one triple or two double bonds. By ozonization of the oil acetone was obtained, but the remaining products could not be identified. The oxidation with permanganate in aqueous solution gave acetone, oxalic acid and some traces of β-oxyisovaleric acid. Oxidation with permanganate in acetone solution gave β-oxyisovaleric acid; oxalic acid and some traces of formic acid; no other oxidation products have been obtained. On the ground of the above investigation I have assumed the following structure formula for the fragrant oil we had obtained:



I have named it 2.7-dimethyl-2.4-octadiene-7-ol in accordance with the Geneva nomenclature. Thus; the product obtained is one of the isomeric terpenic alcohols of the formula $C_{10}H_{18}O$. Comparisons with geraniol

2.6-dimethyl-2.6-octadiene-8-ol

and linalool



2.6-dimethyl-2.7-octadiene-6-ol

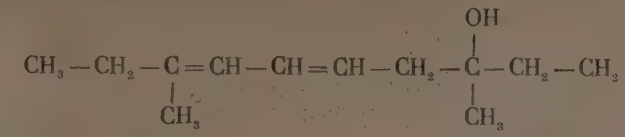
show that the left side is identical in all three compounds whereas the right side is somewhat different. Still it appears that the alcohol I obtained is nearer to linalool. Its specific gravity $d_{20}^{20}=0.868$ approaches that of linalool.

The hydrogenation of 3.8-dimethyl-4.6-decadiin-3.8-diol, obtained by electrolytic hydrogenation of methylethylacetylenylcarbinol also gave an oil with a pleasant perfume of flowers. By repeated fractionation an oil boiling within 120—122° at 7 mm was obtained. In it I ascertained by combustion:

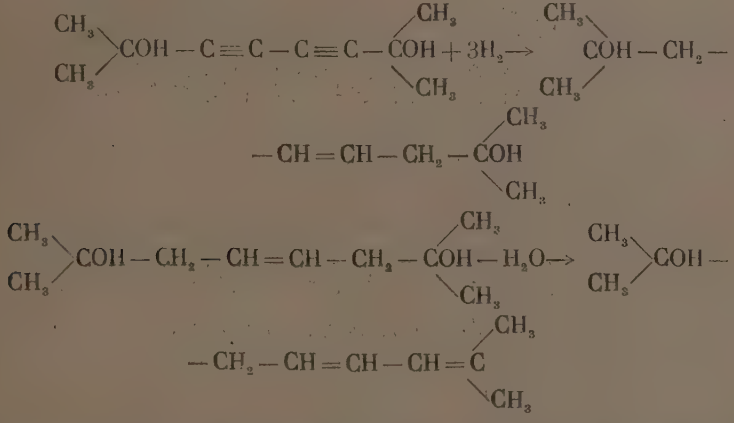
C—79.14%; H—12.33%	Calcd. for $C_{12}H_{22}O$:
C—79.20%; H—12.08%	C—79.12%; H—12.18%

Its molecular weight found was $M=182.2$; while the figure calculated for $C_{12}H_{22}O$ is $M=182$. The hydroxyl percentage by Chugaev-Zerevitinov's method

was 89.2 per cent. No oxidation of this compound has been carried out. By analogy with dimethyloctadienol the formula



and the name of 3.8-dimethyl-3.5-decadiene-8-ol may be possibly assigned to it. For the formation of dimethyl octadienol from diacetylenic alcohol the following scheme may be suggested:



The removal of water may be effected by alkali or bicarbonate present in the electrolyte. My plan to obtain further evidence in favour of the advanced mechanism of the formation of dimethyloctendiol is by attempting to isolate the intermediate hydrogenation products; namely dimethyloctindiol and dimethyloctendiol, and by removing one molecule of water from the latter.

The conclusion to be drawn from what has been stated here is that electrolytic hydrogenation of acetylenic compounds does not proceed according to any single elementary scheme, but has a number of variations. Any variation of the hydrogenation conditions involves far-reaching qualitative alterations of the final reaction products (formation of diacetylenic glycols, terpenic alcohols; etc).

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PHYSICAL CHEMISTRY

ELECTRODE POTENTIALS OF TYPICAL STAINLESS STEELS

By G. V. AKIMOV, Corresponding Member of the Academy, and G. B. CLARK

It is only under conditions making for oxidation that the stability of stainless steels to corrosion becomes apparent, so there is every reason to believe that passivity and passivation processes lie at the very foundation of the strong chemical resistance of iron alloys high in chromium.

In our previous paper (1) we were able to show that by resorting to the method of potential measurement on specimens abraded with corundum while under solution, it is possible to obtain a qualitative and even an approximate quantitative estimate of the influence of a protective film on the electrochemical potential of the metal.

In fact, when the surface of a stainless steel is abraded under solution; there is no cause for any sharp change of the potential to the negative unless the steel has a protective film formed upon it [see (1), § 5). On the other hand; if not the formation of a film, but some facts of internal structure (a change of electronic configuration) should account for the chemical substance of stainless steels; as is asserted by Uhlig (2, 3) in a number of papers; then the potential would not change appreciably on an abraded surface; for the internal «atomic» structure of an alloy cannot possibly be affected by merely rubbing its surface layer off.

The abrasion of specimens under the solution in potential measurement tests has been tried by us on the following steels (Table 1).

Table 1

Nos.	C	Si	Cr	Ni	Mn	Mo	S	P	Cu	Va
1	0.07	0.22	17.25	—	0.32	—	—	—	—	—
2	0.1—0.2	—	27—30	—	—	—	—	—	—	—
3	0.24	0.78	19	—	9.74	—	—	—	—	—
4	0.20	0.97	18.2	—	17.6	—	—	—	—	—
5	0.29	0.42	17.5	3.04	7.78	—	—	—	—	—
6	0.08	0.44	17.73	8.81	0.56	—	0.004	0.041	—	—
7	0.05	0.58	17.2	9.27	0.81	3.38	—	—	0.04	0.08

The specimens of steels 3, 4, 5 and 7 were kept at 1100° C for 10 minutes and cooled in water.

The specimens of steel 1—at 800° C for 2 hours, cooled in air.

The specimens of steel 2 were annealed under industrial conditions.

The specimens of steel 6 were hardened under industrial conditions (1000—1100°C)*.

* The thermal treatment of the steel was so chosen as to impart it the highes possible homogeneity of structure.

The surface of every specimen was abraded with emery paper No. 00, freed from grease by acetone or alcohol, and then the specimens were put into a desiccator for one or two days.

The potential measurements were carried on in solutions of four electrolytes: 3 per cent NaCl; 0.1 *n* HCl; 0.1 *n* HNO_3; 0.1 *n* NaOH.

The results of these experiments are given in Table 2 and represented graphically by the figure*. The circles correspond to the estimates of potential made 5 minutes after the immersion of the samples in the solution which was being stirred continually. The length and direction of the arrow indicate the magnitude and direction of the potential change on a sample with abraded surface. Thus, the point of the arrow corresponds to the value of the potential for filmless metal.

For every solution in the figure there are given along with the values of the potential obtained for the investigated steels, the respective values for the pure component metals.

What has been revealed by the results of the measurements is this.

1) In the 3 per cent NaCl solution the original potentials are very different on different steels. The effect of cleaning by abrasion is to lower the nobility of potentials by as much as 200 to 500 mV, and all the tested steels had their potentials approaching the same value (about 300 mV) which was very near to that for pure iron with abraded surface (the difference being only 40 mV).

2) In the 0.1 *n* HCl solution all steels with the exception of 6 (18-8) and 7 (18-8 with Mo) showed low values of the potential (about −300 mV), very close to that observed with abraded samples in 3 per cent NaCl; the abrasion did not affect the potential. In this case, too, the values of the potential were close to that for pure iron.

Steel 6 (18-8) is rendered somewhat less noble by abrasion and afterwards does not regain its original value of the potential. On the contrary, it even continues to decrease in nobility. Steel 7 (18-8+Mo) is made less noble by abrasion by as much as 100 mV. But immediately after, it regains nobility and the original

Table 2

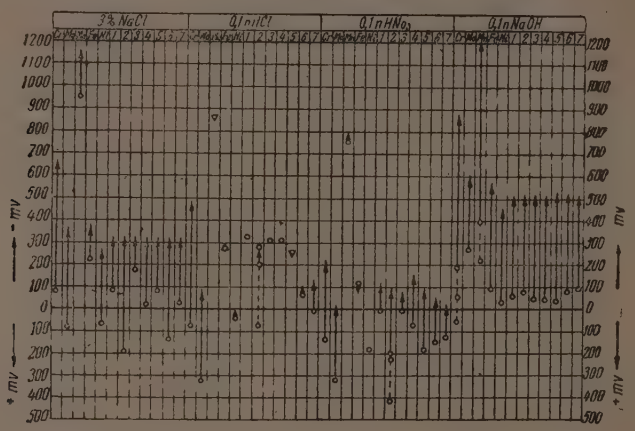
Electrochemical Potential of Various Stainless Steels in Various Solutions
(in mV, averages of at least three measurements)

Steel \ Solution	3% NaCl				0.1 *n* HCl				0.1 *n* HNO_3				0.1 *n* NaOH			
	after 1 min.	after 5 min.	on stirring	on abrasion	after 1 min.	after 5 min.	on stirring	on abrasion	after 1 min.	after 5 min.	on stirring	on abrasion	after 1 min.	after 5 min.	on stirring	on abrasion
1 (17% Cr)	−81	−124	−85	−318	−334	−335	−329	−326	−208	−1	+11	−105	−69	−51	−55	−501
2 (30% Cr)	+151	+166	+197	−311	−259	−300	−200	−278	+545	+300	+200	−95	−93	−74	−75	−511
3 (9% Cr, 9% Mn)	−196	−229	−173	−311	−321	−314	−307	−317	−77	+2	+6	−65	−52	−37	−45	−501
4 (18% Cr, 17% Mn)	−4	−28	−18	−315	−326	−312	−308	−306	−104	−9	+72	−145	−46	−27	−38	−501
5 (17% Cr, 7% Mn, 3% Ni)	−60	−110	−80	−321	−275	−264	−255	−251	−76	+7	+179	−95	−34	−25	−35	−495
6 (18% Cr, 8% Ni)	+100	+100	+139	−298	−119	−116	−60	−100	+480	+148	+152	−38	−100	−78	−79	−521
7 (17% Cr, 9% Ni, 3% Mo)	+12	−34	−28	−305	+7	+4	+15	−118	+450	+120	+123	−18	−85	−96	−96	−514

* The values of the potential are expressed in terms of the hydrogen electrode scale.

value of the potentialis nearly restored. Thus; among the number of the tested steels only the one containing Mo displays a steady electrochemical behaviour in a 0.1 *n* solution of HCl.

3) In the 0.1 *n* HNO_3 solution the values of the potential with all steels were more positive than in the other solutions. The original values were very different. Abrasion activated the potential by 100—300 mV. The difference in the potential values for abraded specimens ranged from +25 to +125 mV.



Electrode potentials of steels and their components. *1*, 17% Cr. *2*, 30% Cr. *3*, 19% Cr; 9% Mn. *4*, 18% Cr; 17% Mn. *5*, 17% Cr; 7% Mn; 3% Ni. *6*, 18% Cr; 8% Ni. *7*, 17% Cr; 9%Ni; 3% Mo.

Here the effect of abrasion on the value of the potential was not so strong as in NaCl and NaOH solutions. Very likely we had not succeeded in measuring the potential during the short interval that there was no protective film on the specimen, since the regeneration of the film is very rapid in a solution of HNO_3. It was observed with all of the tested steels that after abrasion the potential at once fell down to its original value and took even nobler values in time. It is well to point out here that the way in which the surface of a stainless steel is treated has a great influence on the potential. In a solution of HNO_3, for instance; steel 18-8, having a surface abraded with emery paper No. 00, is sharply activaled for the first 5 minutes (by about 350 mV); so that the value of the potential arrives close ot +150 mV. On the other hand; the specimens of the same steel, etched in 5 *n* HCl and afterwards kept at 100—150° C for about 3 hours, showed scarcely any change in potential as time went on (by hours and days), according to the observations made V. P. Batrakov in this laboratory. In that case the value of the potential settled down within +530÷+550 mV. On abrasion the value of the potential was the same in both cases—about—40 mV.

4) In the 0.1 *n* NaOH solution the values of the potential for all steels were on a nearly equal level. Upon abrasion all steels became less noble by 400 to 500 mV. At this time every steel showed a potential value of about—500 mV; i. e. a slightly more positive value than that for Fe. The situation was the same as in the case of NaCl solution.

After the abrasion the potentials of all steels at once regained their initial values and grew nobler still in the course of time.

The conclusion to be drawn from the results of our measurements is that the chemical stability of stainless steels may well be accounted for by the presence of a protective oxide film on their surface. The composition and structure of this film depends upon the composition and structure of the steel and upon the nature of the solution.

The different character of the film upon different steels accounts for the difference in electrochemical potentials.

What is measured on the abrasion of the surface is the potential of the metal deprived of its film. This is why different stainless steels have been observed on abrasion under solution to take nearly equal potential values which were all very near to the potential of filmless iron.

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GEOLOGY

THE BOUNDARY BETWEEN THE CRETACEOUS AND THE PALAEOGENE AT FERGHANA

By O. S. VIALOV

(Communicated by A. A. Borissiak, Member of the Academy, 6.VIII.1943)

In describing the Isfara section (South Ferghana), the author (1) has separated out the following groups of beds in that portion of the formation which is transitionary from the Cretaceous to the Palaeogene.

XV. A gypsum formation with intercalations and lenses of greenish marls. This is the so-called «i» horizon; according to the nomenclature of K. P. Kalitzky, or gypsum beds of Goznau, as they are now usually named following the author. Thickness, 26 m.

XVI. Clays; in the lower part, pure, plastic, olive-coloured; higher up they gradually become increasingly arenaceous, alternating in the middle portion of the group of beds with loose, highly argillaceous, dark-grey sandstones. They are followed again by purer plastic foliated dark-grey clays; in their upper horizons thin bands of loose grey sandstones are present. In the group of beds described fish scales, a shark tooth, remains of crabs, indistinct impressions of pelecypods and gastropods have been found, as well as scarce vegetable fragments. Owing to the poor state of preservation, it proved impossible to determine the fossils. An analysis of microfauna made on the specimens taken showed the following species of foraminifers, as determined by Rumyantzeva (2): *Ammodiscus* sp., *Haplophragmoides excavatus* Cushm. et Waters, *H.* ex gr. *glabrus* Cushm. et Waters, *H. nana* sp. n.; *Gaudryina* ex gr. *rugosa* d'Orb., *G. isphariniса* sp. n., *Trochammina* ex gr. *teasi* Cushm. et Elliser. This fauna furnishes no clue for a determination of the age. Thickness, 35 m.

XVII. Quartz sandstones, massive, non-compact, light-grey, greenish and yellow, with small ferruginous concretions. In the roof a bed of a compact somewhat marlaceous yellow spotted sandstone is distinguished (1.50 m) with a figured lower surface (bas-relief interlacements of nodose arenaceous concretions of various shapes). In this bed there are found numerous remains of fauna, represented exclusively by imprints and sandy casts (*Cardita* sp., *Turritella* sp., *Natica* sp., and others). This fauna is poorly preserved, and has not yet been subjected to study.

For the group of beds described has been suggested the name of Sulyukta sandstones. In the mining practice of the «Kalininnepht» Trust they have been known by the name of «First sands»; and are at present provisorily designated as the IX oil-bearing horizon. Thickness, 14 m.

XVIII. Greenish clays and sandstones; some horizons contain numerous fish remains (scales and fragments of small bones). In the sandstones there are seen numerous sandy concretions of various shape; these evidently present traces of crawling of worms. In the upper part of the group of beds there appear greenish dolomitized clayey marls with gypsum druses and an abundant fauna (which is, however, so crusted as to present a great difficulty for identification) of gastropods (*Turritella* sp., etc.) and of pelecypods [*Corbula* (s. str.) sp., *Modiola*

sp., etc.). Of microfauna only one specimen of *Eponides* sp. has been discovered. Thickness, 11 m.

XIX. White porous dolomitized limestones and dolomites; gypsum-bearing, with numerous remains of a typical fauna of the Bukhara stage (3): *Corbula* (*Cuneocorbula*) *angulata* Lam., *C. asiatica* Vial., *Modiola jeremejewi* Rom.; *Potamides* (?) *romanowskyi* Vial., etc.

This is the «K» horizon after the nomenclature of K. P. Kalitzky; in the mining practice it has been so far designated as the VIII oil-bearing horizon.

The thickness of the horizon described attains 3 m; but more frequently it is much less; fauna typical of the Bukhara stage is far from being present, although the limestones and dolomites carry; as a rule; a profusion of fossil remains.

XX. The gypsum-bearing series of the Suzak stage. In the lower portion it consists of an alternation of limestone clays; reddish and dirty-green; with gypsum; isolated bands of red sandstones are encountered. Higher up begin to prevail greenish clays; also alternating with gypsum. The beds contain no fauna. A microfaunistical analysis has also given negative results.

As to the age of the groups of beds described, the author has stated that the XV gypsum horizon refers, probably; to the Cretaceous; XIX; undoubtedly; to the Palaeogene (Bukhara stage); XVI quite probably belongs to the Cretaceous (4).

Quite different is the character of the section of the upper part of the Cretaceous and lower part of the Palaeogene observed in North-eastern Ferghana (Kizyl-Yar). Here the so-called «radiolite» horizon is developed; consisting of several horizons of limestones and marls; projecting in cornices down the slope and separated by beds of red clays. The thickest and most persistent is the last, upper horizon which contains radiolite remains. This is overlain by beds of the so-called «over-radiolite» formation, composed of dark brown-red clays; not infrequently arenaceous; occasionally with sandy bands and lenses; highly gypsum-bearing. Gypsum is present in a large quantity; now in the form of veins, and then as rounded concretions up to 30 cm across. In the uppermost portion of this group of beds (9.50 m) pink sands and clays are developed. The «over-radiolite» series is overlain by rocks of the Bukhara stage, beds of gypsum with thin limestone or dolomite bands not infrequently passing to gypsum along the strike. In some of the limestone bands a very characteristic fauna is present, permitting at once to establish the Bukhara age of the beds [*Corbula* (*Cuneocorbula*) pl. sp.; *Potamides* (?) *romanowskyi* Vial.].

In attempting to compare the two sections; the author (4) felt inclined to correlate the «radiolite» horizon of Kizyl-Yar with the Gonzáu gypsum beds (group of beds XV) of Isfara section. As probable analogues of the brown-red «over-radiolite» series of Kizyl-Yar he considered the XVI—XVIII groups of beds of the Isfara section, pointing out a number of difficulties involved in such a correlation. To draw a boundary between the Cretaceous and the Palaeogene; and to correlate the Isfara and Kizyl-Yar types of sections is one of the most important; but also most difficult problems of the stratigraphy of the Cretaceous and Palaeogene of Ferghana. The above exposed opinion of the author has been adopted in literature. At present I suggest a different solution of the problems discussed.

The new treatment has originally been based on the following considerations: the two sections being within the same; comparatively small; basin; the variations of the shore-line should affect them in a similar way; similar, certainly, not in the quantitative sense; for it is evident that near the shore the changes produced are more important; but in the sense of the trend of the process; while the sea advanced in both places, an increase of depth should be observed; if in one section the facies would become shallower; a change of facies in the corresponding beds of the other section should also be expected.

We are justified in presuming a retreat of the sea at the moment when the radiolite limestones gave way to red over-radiolite clays with gypsum. The same process—shallowing of the sea and formation of a closed lagoon—may be presumed to have taken place at the period of formation of the Goznau gypsum formation (XV group of beds of the Isfara section).

In examining the further change of facies in a vertical direction; we see a new deepening at the time when the Goznau gypsum beds were replaced by green and grey clays of the formation crowned by a limestone bed with a fauna of the Bukhara stage (XIX group of beds).

In the Kizyl-Yar section the over-radiolite red clays; the marine origin of which has by no means been proved either, are likewise covered with gypsum beds with limestone bands containing a marine fauna of the Bukhara stage.

Thus; the idea suggests itself that the Goznau gypsum beds should be correlated with the over-radiolite horizon of Kizyl-Yar instead of the radiolite. If so, the layers covering the Goznau gypsum in the Isfara section should be referred to the Burkhara stage. The latter will then comprise the XVI--XIX groups of beds of the above-described Isfara section.

The assumption as to the necessity of lowering the boundary of the Bukhara stage in the Isfara type sections has recently been confirmed faunistically. During a trip to Isfara in October, 1942, with the staff of the Central-Asia Expedition of the Petroleum Institute; some specimens of oysters were found in the Sulyukta sandy series (XVII). Although they were rather poorly preserved; it was possible to determine at least one specimen with sufficient certainty as *Ostrea bellovaeina* Lam. var. *trinkleri* Böhm.

This species, spread mainly in North Ferghana and known also from Kashgar, does not pass beyond the limits of the Sogda division. It occurs only in the upper portion of the Bukhara stage and in the lower part of the Suzak stage; and in any case is an evidence of the enclosing layers belonging to the Palaeogene, rather than to the Upper Cretaceous.

The age of the radiolite horizon si universally considered as Santonian; without any reservations. Such a unanimity of opinion is based on the determination by Douville (1914) of two species of rudistids, originating from this horizon of the Kizyl-Yar (Suzak) section. Douville has determined *Biradiolites pracingens* Toucas and *Apricardia toucasi* Douv. These species are confined to Santonian beds in the Beausset basin at Provence. The establishment of the age of the radiolite horizon in the Kizyl-Yar section is generally of great importance, since it is widely spread in Central Asia (Eastern Ferghana; Tashkent region, Kizyl-Kumy; the Alai and Trans-Alai ranges; Darvaz; the Bukhara depression; etc.). The opinion as to the Santonian age was extended to other regions; too. On the basis of such a determination of age for certain places; arguments were advanced as to the absence of the Upper Senonian and Danian; the existence of a break; the manifestation of a phase of folding, etc. Only Rengarten ([6]); followed by Borneman and Ovchinnikov ([1]), referred the rudistid limestones of the Trans-Alai range to the Upper Senonian.

The author has already had the opportunity to write that he has succeeded in demonstrating the Upper Senonian (Maestrichtian) and not Santonian age of the radiolite horizon ([6]). This permits to establish the boundary between the Cretaceous and the Palaeogene at Ferghana. It is quite clear that the over-radiolite red clays covering this horizon should be referred to the Danian stage. Higher up begins a gypsum formation with limestone bands with a fauna of the Bukhara stage of the Palaeogene. Thus; the boundary of the Cretaceous and the Palaeogene in north-eastern Ferghana follows the roof of the over-radiolite clays. In South Ferghana, that is in the Isfara type sections; the over-radiolite clays are stratigraphically corresponded to the Goznau gypsum beds. Consequently, they also refer to the Danian; and the boundary between the Cretaceous and the Palaeogene passes along their roof.

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HISTOLOGY

ISOELECTRIC POINTS OF THE CAPILLARIES

By G. ROSKIN

(Communicated by L. A. Orbeli, Member of the Academy, 24.XI.1943)

The nature of the processes which take place in the histohaematic and haematoencephalic barriers are intimately related with the properties of the cells of which these most important regulatory systems of the organism are formed.

One of the principal features responsible for a number of cytophysiological peculiarities consists in the electrical-colloidal properties of the cytoplasm, of the nucleus and of other important components of the cell.

The investigation of the isoelectric points of endothelial cells, which is likely to permit of a deeper insight into those highly intricate domains of subtle analysis of the cytophysiological properties of capillary cells, is therefore of unquestionable import for the understanding of the laws underlying the regulatory functions of the organism.

The method of determining the isoelectric points (IEP) on histological preparations has been developed by Pischinger (1926). As a basis for his method he took work done by Bethe, in which this author had shown the significance of the dyestuff solution's pH for the subsequent effect of staining. Pischinger found that when histological sections are stained with highly dispersed acid or basic dyestuffs dissolved in buffer mixtures of a definite pH; there may be observed leap-like drops in the intensity of staining. Model experiments carried out with the aid of cataphoresis enabled Pischinger to establish that the moment of colour vanishing coincided with the isoelectric points of the object investigated. Many students, viz. Zeiger (1930), Mommsen (1927), Iasuzumi (1933; 1934), Fautez (1936), Ikeda (1935; 1936); Roskin and Romanova (1937), Roskin and Nastiukova (1940); my collaborators Radkevich (1938) and Solovieva (1936), made use of this method for determining the isoelectric point in normal and pathological cells. Pischinger's method has critically been revised by Zeiger (1930, 1938), who brought out the influence of fixation upon the shift of cellular IEP. Solovieva found the composition of the buffer mixture to have an influence upon the determination of the isoelectric point. A number of critical suggestions as to the relation between the IEP in a fixed and in a living plasm may be found in a paper by Ries and Gersh. Pischinger's method was analysed in detail by Levine (1940) who pointed out that the determination of IEP is greatly dependent on the composition of the buffer solution and on the concentration of the dyestuffs applied. All that has been said here made me conclude that by this method it may be possible to obtain data on the isoelectric points of the cells comparable only in the case of a strict identity of staining conditions. For the r e l a t i v e v a l u e s obtained when working after Pischinger's method, I suggested the name of «c o l o u r i n d e x o f c e l l s». A strict identity of the method being observed, the colour indices may serve both to characterize the cells and their organoids and to analyse the functional or pathological changes taking place in them. The fitness of the

method for all these purposes has been well demonstrated in works by Roskin and Romanova, dealing with the effect of medicinal substances on the cell; and also in those of Roskin jointly with Nastiukova; devoted to changes in the sorption properties of erythrocytes in normal and cancerous animals.

As material for the present investigation use was made of capillaries of the various organs of the frog, viz. of the liver, kidneys; tongue and cortical tissue of the brain. Small particles of the organs were fixed during two hours in absolute alcohol and then embedded in paraffin. The sections were stained with a basic dye; the methylene blue. Being not in position to apply as an acid dyestuff the cyanol (after Pischinger), or crystal-ponceau (after Zeiger; 1930); we chose for this purpose fuchsin S which also gives satisfactory results on the whole. The dyes were prepared in the form of 0.1 per cent solutions; and then mixed with equal parts of *N*/100 phosphate «buffer» solutions of a pH ranging within an interval of 4.2—7.85. For more acid solutions a mixture of citric acid and phosphate solution was used. The pH of the separate solutions were spaced at 0.2. Upon a 10 minute staining the preparation was rinsed with a *N*/200 buffer mixture of the same pH as that of the dyestuff applied. After being stained with methylene blue; the preparations were fixed with an 1 per cent solution of ammonium molybdate; rinsed with water and usually immersed into balsam. Preparations stained with an acid fuchsin were washed with water, quickly passed through alcohol and xylol, and immersed in balsam. The following conventional denotation of the colour intensity was adopted: scarcely detectable +; clearly detectable + +; intense + + +.

When staining with buffer solutions of methylene blue; say; lingual capillaries, we become aware of the fact that the nucleus fails to stain within the pH interval from 2.8—3.6. A scarcely noticeable staining appears at pH = 4.0; and a very intense one at pH = 4.2. According to Pischinger's theory; we might assert that the isoelectric point of the nuclei of the lingual capillaries endothelium lies at about pH = 4.0. Further on, with pH = 4.2—6.2 a clear-cut staining of these nuclei is observed. The plasm of the respective cells starts staining much later: up to a pH = 4.2 the plasm remains colourless; with pH = 4.2—5.0 a slightly detectable blue tinge is observable. And it is not until a pH = 5.2 that the plasm of endothelial cells stains an intense blue. Thus; Pischinger assigns the interval of pH = 5.0—5.2 to the isoelectric point of the plasm. Those two points, pH = 4.0—4.2 for the nucleus and pH = 5.0—5.2 for the plasm, give us an idea of the relative isoelectric points of the endothelium of lingual capillaries; they also may serve to characterize the physical-chemical peculiarities of the cells. The characteristic may be supplemented by observations carried out with acid fuchsin: when stained with this dyestuff, the nucleus remains colourless irrespective of the pH of the solution, while the plasm does not stain until pH has dropped to 4.2, assumes a more distinct coloration with pH = 4.0; and stains intensely with pH = 3.8. These figures which denote the points at which the nucleus or the plasm begins to take on a basic or an acid dye give on the whole a definite characteristic of the cells; being their colour indices. It should also be noted that the pericytes (Rouget cells) which closely adjoin the capillary wall; possess colour indices different from those of the cell of lingual endothelium.

The colour indices of the endothelial cells of the capillaries of the brain cortex show different values. When stained with methylene blue; the nuclei of the endothelial cells of the cortex assume a scarcely noticeable blue tinge with pH = 3.0; the coloration grows deeper at a pH = 3.6—3.8; while with pH = 4.0 a very intense staining is observed. The plasm of those cells stains but poorly at pH = 2.8; a more distinct coloration is observed with pH = 3.0—5.2; while with pH = 5.4 the plasm stains dark-blue.

When stained with acid fuchsin, the nucleus of the very same cells starts staining feebly at pH = 4.4, more distinctly with pH = 4.0. and intensely with pH = 3.8—2.8. The plasm takes on a faint colour at pH = 5.0 and stains deep with pH = 4.8—2.8.

A subsequent study of the renal capillaries (Bownan's capsule) and those of the

liver showed that their endothelial cells have characteristic colour indices of their own. The above said permits of the assertion that the nuclei and plasms of endothelial cells in various organs differ as to their physical-chemical properties, having different isoelectric points. If for the sake of scientific prudence we refrain from claiming that our observations give an idea of the absolute isoelectric points of the cells investigated, nevertheless, when comparing the effects of staining in cells, we may speak of relatively different isoelectric points of the cellular components of endothelial cells in capillaries of different organs. The results obtained by us may appear rather surprising if the common origin of the endothelial cells and their morphological similarity be taken into account.

On the other hand, we cannot ignore the work by Fautez (1936), who showed that the cells of different sections of the reticular-endothelial system may differ as to their IEP. One must not believe, however, that these distinctions of the endothelial cells of the capillaries do only reflect their definite functional conditions. The fact is that the isoelectric points of the cells (as determined according to Pischinger) are very stable, provided, of course, that the conditions of fixation and subsequent treatment of the tissues be identical. This has been brought out in works by Zeiger (1933), Benner-Patzelt (1932), Roskin and Romanova, Roskin and Nastiukova, as well as in those of my collaborators, Radkevich and Solovieva. From these studies it followed, moreover, that a highly efficient factor is necessary to bring about changes of the isoelectric points of the cells organoids. Thus, for example, changes of the isoelectric points in protozoic cells (*Trypanosomata*) may occur under the influence of considerable doses of chemotherapeutic substances (Roskin and Romanova).

By the data exposed here we are led to a conclusion that the cells of capillaries of various organs differ as to their physical-chemical properties. And this circumstance contributes materially to our knowledge of the regulatory mechanisms of the capillaries of various organs.

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MICROBIOLOGY

ON THE PHYSIOLOGICAL PECULIARITIES OF THE YELLOW STRAIN OF TOBACCO MOSAIC VIRUS

By V. L. RISCHKOV, A. M. VOVK and T. S. ALEXEEVA

(Communicated by L. A. Orbeli, Member of the Academy, 27.IV.1943)

While observing great numbers of tomato plants affected with the mosaic disease (*Nicotiana* virus 1 Allard), we detected in some of them sharply defined light-yellow spots. If a tomato plant is inoculated with juice from such a spot, instead of the usual picture of mosaic disease, a more severe disease is found to develop; this is characterized by the appearance of yellow or nearly white spots on the youngest leaflets, that develop upon infection. The spots display a strongly depressed hypoplasy as compared to the surrounding tissue. In the subsequent leaves may appear that will be entirely devoid of chlorophyll. The plants infected are much depressed in their growth, and separate areas of leaves and entire leaves soon begin to dye off. In tobacco plants the virus also produces the yellow mosaic and a peculiar pattern, somewhat different from that of the typical mosaic. The yellowing does not infrequently concentrate in the region of the veinlets, or spreads from the edges of the leaves towards their centre. The yellowing is followed by necrosis and dying-off of the leaves. The virus isolated by us produced in *Nicotiana glutinosa* local necroses, like *Nicotiana* virus 1. The plants affected by the yellow mosaic here described contain in their cells typical hexagonal crystals (D. I. Ivanovsky). These circumstances make us consider the virus isolated by us as a yellow strain of the tobacco mosaic virus. A great number of such strains has been described in literature. The one isolated by us belongs to the group of viruses which by one almost total decoloration of leaves it brings about, approaches to the white strains.

MacKinney (3) was studying in detail the relations between the two strains of tobacco mosaic, the green and the yellow. According to this author, the infection of tobacco plants with one of these strains prevents their infection by the other. And when a tobacco plant is inoculated with a mixture of both strains, even if there is a great quantitative prevalence of the juice of the yellow mosaic, the green strain gradually gains advantage in the plant and completely supplants the yellow one. We also were able to observe in our experiments that tobacco plants infected with green mosaic defy infection with the yellow strain, and inversely; in experiments with tomato plants, however, no such regularity could be observed. A tomato plant attacked by a typical mosaic, upon inoculation with the yellow strain was found in the subsequent to develop isolated tissue sections of a light-yellow colour, in the case of a mixed infection symptoms typical of the green strain were prevalent; yet, separate yellow speckles appeared here and there, and the yellow strain was not suppressed entirely.

The yellow and the green strains showed a somewhat different attitude towards high temperatures. As may be seen from Table 1; the yellow strain becomes utterly

inactive at 86° C, whereas in the green strain complete inactivity sets in not until about 90°C.

Table 1

Inactivation of the Yellow Strain of Tobacco Mosaic Virus (as induced by heating during 10 minutes)

Plant	Temperature in °C	Inoculated	Showed signs of disease
Tomato . .	90	10	0
» . .	86	9	0
» . .	80	20	1
Tobacco . .	80	10	0
Tomato . .	78	9	1
» . .	70	10	4
» . .	No heating	5	5

Note: The juice that served for inoculation sometimes contained admixture of the green strain; in such cases at 80°C and even at lower temperatures a large number of plants showed signs of green mosaic. The table above contains data bearing on the development of symptoms of the yellow mosaic alone

Table 2

Effect of H_2O_2 upon the Green and the Yellow Strains of the Tobacco Mosaic Virus

H_2O_2 concentration in %	Strain	Number of necroses per leaf
0.01	Green	55.0
0.01	Yellow	4.5
0.05	Green	77.0
0.05	Yellow	5.9
0.10	Green	3.6
0.10	Yellow	1.3
0.15	Green	1.0
0.15	Yellow	0.0

The yellow strain also proved more susceptible to the oxidizing effect of hydrogen peroxide, as may be seen from Table 2. It should be noted that the influence of hydrogen peroxide has not been observed to bring about any changes in the yellow strain that would tend to weaken the symptoms produced by the latter. It either lost its acitivity or else remained virulent, i. e. able to call forth a complete discolourment of the leaves and their dying-off.

Inactivation of the yellow and green strain by means of H_2O_2 was tested along with the experiment described above; one half of a leaf of *N. glutinosa* was inoculated with the green strain, another with the yellow one, which makes the results given in Table 2 comparable in pairs. The figures represent the means of necroses per half of a leaf; each test comprised from 7 to 10 leaflets of *N. glutinosa*.

Experiments with a 0.15 per cent concentration of H_2O_2 were carried out with three different pH, viz. pH =8.3, 4.5 and 7. The results obtained were identical in all cases.

Having observed that the green strain compares favourably as a competitor with the yellow one, MacKinney suggested the idea that the green strain may have a higher rate of reproduction in the plant. In order to check up this assumption, special tests were carried out. Halves of the same tobacco or tomato leaf, after being severed from the plants, were infected by regularly spreading over the leaf surface juice containing either green or yellow strain. The half-leaves were kept in a humid exsiccator at room temperature during several days, after which the titre of the virus in them was determined after the number of necroses per leaf. It stands to reason that the comparison of the virus titres was made again by the method of two halves. In order that the results obtained in these tests be statistically significant, several dozen of leaves of *N. glutinosa* were under experiment. In Table 3 their number is given in the column denoted as number of replicates.

From Table 3 it may be seen that the accumulation of the green strain always proceeds at a higher rate than that of the yellow one, this difference being still more conspicuous in tomato than in tobacco.

When comparing the characterisic features of the green and the yellow strain of *Nicotiana* virus 1 it should be pointed out that the yellow strain is invariably found to be less adaptive to parasitism than the green one. It is not only less stable and accumulating at a lower rate, but the morbid condition brought about

Table 3

Rate of Reproduction of Green or Yellow Strain of Tobacco Mosaic Virus in Severed Leaves of Tobacco and Tomato

Virus accumulating leaves	Titre of virus		Number of replicates
	Green	Yellow	
Tobacco . .	8.0	1.4	33
» . .	9.0	5.0	34
» . .	48.0	10.0	34
Tomato . .	34.0	1.0	27
» . .	43.0	2.0	35

by it is much more severe than that produced by the green strain. A parasite which badly affects the plant stands at a lower step of adaptivity to the plant than a parasite which calls forth slighter injuries, being therefore able to accumulate in greater quantities and during a longer period of time. A tomato plant affected with the yellow strain often perishes at early stages of development, while affection with the green strain does not prevent the plant from bearing abundant fruits. Consequently, the virus of the yellow mosaic cannot accumulate otherwise than in negligible amounts. Indeed, under natural conditions, in a greenhouse, the yellow strain is encountered only in combination with the green one, being able to take possession only of small spots in individual plants, which is manifest in solitary yellow speckles.

We still know very little about the strains of tobacco mosaic virus encountered in this country. The earliest information on the yellow strain may be found in papers by Rischkov, Mikhailova and Pivovarova (2); a strain resembling that of aucuba-mosaic has been described by Goldin (1). A further study of the various strains of this virus which is so widely spread and inflicts so heavy economic losses, is not only of theoretical, but of practical importance, as well.

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PLANT PHYSIOLOGY

GROWTH REACTIONS IN PLANTS UNDER EXCESSIVE WATERING

By N. S. TURKOVA

(Communicated by N. V. Tsitsyn, Member of the Academy, 29.III.1943)

In the neighbourhood of Alma-Ata the lodging of crops is a rather frequent phenomenon. The plants there are sometimes observed to lodge in great numbers under conditions that do not favour strong growth—among thin or weakly developed stands. Then any possible deficiency of light is certainly out of the question, and in most cases there is no overabundant supply of nitrogen. Of the factors known to be responsible for lodging (²) there remains therefore only one—the conditions of water supply. In this paper we are to discuss some peculiar features of the effect of watering and heavy rains on the character of plant growth.

In the middle of June 1942 rains continued for several days (from June 12 to 16) and extensive lodging was observed among various crops. Maize, wheat and many other grains suffered heavily from it. In order to clear up the part played by growth reactions in mass lodging of plants, several plots planted with tomatoes and potatoes were subjected to careful inspection on the 15th of June. These plants were chosen because it is among the *Solanaceae* that growth reactions are particularly strong and typical (³).

On all potato plots a clearly expressed epinasty of leaves was stated, and some specimens, mainly the tallest, were slightly drooping. This phenomenon was even more forcibly expressed in tomatoes. Their leaves were turned in downwards, many stems showed curvature, and the top was no longer in the vertical position. On grounds saturated with water—in the depressions and hollows—these changes in the geotropic reaction of the above-ground organs were particularly conspicuous. In that state the plants remained all the time that the rains and overcast weather continued. But on the very first day that the sky had cleared up, their tops began stretching upward; and part of their leaves—in the first place the youngest—went up. After two or three days of sunny weather most of the plants looked more or less normal. It was, of course, only natural to find that those plants on more thoroughly wetted soil had recovered later. Loosening of the soil helped such plants to get sooner free from epinasty. Ten days after the weather had cleared, some of the maize and other grain crops—mainly their younger parts—also began rising. However, on a neglected, badly tilted plot planted with maize where the plants stood sparsely and had poorly developed, because the soil had not been loosened after its saturation with rain water; they straightened but little and many of them were observed lodging until harvest. On the other hand, the recovery of plants from lodging and epinasty was greatly hastened by soil loosening.

It appears from numerous observations of the growth of plants as affected by watering that in the case of *Solanaceae* an overabundant water supply («by flooding») calls always forth a more or less pronounced epinasty of leaves, which is further strengthened by the formation of a crust on the excessively moist soil.

Now the soil in the vicinity of Alma-Ata—on the territory of the Botanical Gardens and adjoining grounds—is that of a valley, hydromorphous and such as may be classed with light chestnut soils strongly modified by watering. It easily becomes puddled and forms a crust. In all cases when the conditions favour the lodging of grain crops, a strong weakening of the negative geotropism is observed in *Solanaceae*. The same phenomenon, though outwardly not so distinctly expressed, will be noticed on careful inspection in cereals. So it seems to be quite certain that the lodging of plants by heavy rains or excessive watering is attended by a weakening of the negative geotropism in their aboveground organs. Some data on the rôle of the geotropic reaction in the lodging of cereals have been given by the author elsewhere.

When a ground becomes swampy by rainfall, the outward appearance of tomatoes growing on it is strikingly similar to the usual habitus of plants that were under the influence of ethylene or other reducers. This likeness is certainly not a matter of chance and appears to mean a great deal: it shows that with an excess of moisture in the soil, especially in a structureless soil, the plants growing on it suffer modifications which are basically identical with those produced by reducers —the normal oxidizing regime of their tissues is sharply disturbed. The reason may easily be understood, if we take into consideration that the water in the soil is an antagonist of the air.

Somewhat earlier the author was able to discover in the leaves of the plants suffering epinasty through the action of ethylene a sharp depression of iodine-reducing activity of the tissues and a decrease of the respiration rate (measured in terms of the evolved CO_2) subsequent to a short period of its intensification. On the other hand, the spraying of the leaves with a weak solution of hydrogen peroxide resulted in hyponasty, and both the respiration rate and the content of iodine-reducing substances were then increased (4).

I have observed in my experiments that in the plants acted upon by ethylene or heteroauxine the content of ascorbic acid (vitamin C) falls down abruptly (Table 1). As the epinasty of leaves produced by the reducers expires, the content of vitamin C approaches the figures shown by the control plants [the ascorbic acid was estimated according to Bukin (1)].

Table 1

Content of Ascorbic Acid in Tomato Leaves as Affected by Spraying with Heteroauxine and Ethylene Solutions (200 ml per plant. Plants sprayed June 19, 1939, Moscow. Outset of flowering. Leaves of the 7th and 8th node from below)

Experimental sets	Time of sampling	Condition of leaves (deviation from vertical)	Content of ascorbic acid in 100 g of abs. dry leaves	
			mg	% to control
Control (spraying with water)	June 20 (24 hours after spraying)	Normal (deviation 30—45°)	258.00	100
Do	June 25 (5 days after spraying)	Do	233.20	100
Heteroauxine 0.001%	June 20	Epinasty (deviation 120—150°)	76.97	29.83
Do	June 25	Expiration of epinasty (deviation 50—75°)	188.0	80.62
Ethylenated water	June 20	Epinasty (deviation 120—150°)	77.45	30.02
Do	June 25	Expiration of epinasty (deviation 50—75°)	164.00	70.32

Table 2

Iodine-Reducing Activity of Tissues as Influenced by Deviation of Organs from the Vertical

Samples	Geotropic reaction	Mls of 0.01 *n* I per 100 g
Tomatoes after three rainy days. leaves from middle nodes	Strong epinasty (deviation from the vertical 100—150°)	45— 70
Leaves from the same nodes after 2 days of sunny weather	Epinasty expired (deviation 40—75°)	108—150
Wheat at the outset of earing. Lower internodes (I and II) at the time of rising	In almost horizontal position	40— 55.5
Middle internodes (III and IV)	Half-risen	63— 78
Upper internodes (V and VI)	Near to vertical	99—110

Table 3

Iodine-Reducing Activity in Plants of Different Growing Habit

Name of plant	Part tested	Position of organs	Mls of 0.01 *n* I per 100 g
Convolvulus arvense L.	Shoots with leaves	I. Base of shoot running into earth	7.4
		II. Middle part prostrate horizontal	16.9
		III. Top slightly raised	22.2
Rubus caesius	Young not lignified parts	I. Horizontal part of shoot	37.6
		II. Upper part 20 cm from growing point	59.0
		III. Top, point drooping over, struck roots	34.0
Tradescantia procumbens	Leaves	Shoots hanging down	14.3
	Stems	Do	11.9
Ceropegia woodsii Schlecht.	Shoot tops with leaves	Hanging down	25.9
Ceropegia bulbosa Roxb.	Do	Do	26.6
Fittonia Verschaffeltii	Shoots with leaves	Prostrate	28.1
Fittonia argyroneura	Do	Do	32.3
Begonia semperflorens Link.	Leaves	From prostrate shoots	20.5
Hemp, weed, *Cannabis ruderalis* Janisch. Flowering	Leaves of female specimens	Upright plants	290
	Leaves from male specimens	Do	342
Gossypium hirsutum. Outset of flowering	Leaves from middle nodes	Do	255
Sunflower *Helianthus annuus.* Termination of flowering	Leaves from middle nodes, ageing	Do	148
Ricinus communis L.	Shoots of third growth with leaves	Upright shoots	222
Spring wheat *Persicum.* Spine formation	Leaves from middle nodes	From not lodging plants	190—267
	Straw with leaves from 5th and 6th internode	Upright straw	99—110
Rheum alpinum L.	Leaves of middle nodes	Upright plants	181.3
Euphorbia biglandulosa	Do	Do	168.6

The measurements of the iodine-reducing activity of the tissues were made at the period of heavy rains at Alma-Ata. An extract was prepared with 2 per cent HCl and titraded with 0.01 *n* solution of iodine.

According to some earlier data secured by me ([3], [4]), the gradual weakening of the negative geotropism of the shoots and leaves in the process of the natural ageing of a plant is linked up with the decrease of the respiration rate, the depression of the reducing activity of the tissues and other indicators of the weakening of oxidation-reduction processes.

It has been brought into evidence by numerous estimations that prostrate, drooping and creping plants differ from those of upright habit in that the tissues of their aboveground shoots show a comparatively low reducing activity. This is illustrated by the data of Table 3. The samples were taken on July 1941 from the nurseries of the Alma-Ata Botanical Gardens.

It will be apparent that all deviations from the vertical habit of growth, no matter how they originated—in the process of natural ageing, or from the action of reducers, or as an inherent peculiarity of the particular plant form—are definitely related to a low content of ascorbic acid and other reducers in the tissues. To discuss the nature of this relation would be premature at this juncture.

The likeness between the reaction of plants to excessive watering, which in the case of cereals is usually concomitant to lodging, and their response to treatment with reducers appears to deserve particular attention. From the data referred to it may be presumed that in the case of cereals: 1) growth reactions ensuing from the weakening of the upright habit of growth play a prominent part in lodging and 2) one of the essential factors in lodging under excessive water supply is poor aeration of the soil, which interferes with the normal run of redox processes in the tissues.

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PLANT ANATOMY

ON THE STRUCTURE OF SPERMODERM OF THE WHEAT KERNEL AND ON PROTANDRY

By V. G. ALEXANDROV and O. G. ALEXANDROVA

(Communicated by L. A. Orbeli, Member of the Academy, 3.VIII.1943)

In a ripe kernel of all cereals the spermoderm has invariably the appearance of a very thin membrane. No characters of a cellular structure of the spermoderm can mostly be revealed unless special reagents are applied which cause swelling of the cell-wall substance. In some of the cereals the spermoderm is quite colourless (white-grained forms), in others it is impregnated with substances of a rather vivid yellow-red colour (red-grained forms). The structure is a quite simple one, if any structure there is at all. But such a primitive simplicity of the structure is known to be a result of the intense metamorphic processes which the integuments of the ovule underwent during the period of formation and ripening of the seed. These enzymic processes are so intense that within the short interval of time that separates, say, the milk ripeness of a wheat kernel from the state of wax ripeness, from the two integuments that give rise to the spermoderm, nothing is left except a membrane, deprived of any trace of cellular structure. This membrane is sometimes so thin as merely to be spoken of as a few cuticular pellicles sticking together. In order to conceive the real nature and the origin of the structure of the kernel's spermoderm, it is necessary to gain a deeper insight into the history of its development.

All students are unanimous in acknowledging the participation of the inner integument in the formation of the spermoderm of a ripe kernel. As for the external integument, there is conflict of opinion: some writers believe the external integument to participate in the building of the spermoderm along with the inner one; others suppose it to dissolve without leaving any trace at a very early developmental stage.

However, recent data, as well as a critical analysis of data of earlier investigations (1) have shown that cases of participation of the external integument in the building of the spermoderm are not so infrequent, and not only possible, but even peculiar to certain wheat forms, and may even occasionally be predicted from the course of development of the kernel. What are then the causes underlying the preservation of the vestiges of the external integument, and what is responsible for its dissolution? To our knowledge, nobody has so far attempted to answer those questions. Yet, the peculiarities of the structure of the kernel's spermoderm present, alongside of their theoretical interest, a considerable practical importance (2).

In our studies of wheats we were more than once confronted with vestiges of the external integuments at various stages of preservation. In some wheat varieties the external integument is subject to disintegration and dissolves very rapidly; in others it dissolves much slower, being occasionally preserved until the kernel is ripe. These variations in the rate of dissolution of the external integument depend on the peculiarities of flowering inherent in a given variety.

Let us analyse the history of the external integument in two wheats: *Triticum dicoccum ferrum*, German spelt, and *T. vulgare lutinflatum* (with swollen scales); the soft wheat from China. The wheats were grown and observed in the field of Pushkin, Leningrad province, at the All-Union Institute for Plant Breeding. Anatomical analysis was carried out in the Anatomical Laboratory of this Institute, in 1940.

The biology of flowering of these two wheats is rather different. In the spelt flowering takes a rapid course. The anthers disclose and pollinate often during no more than one day; they do not protrude from under the flower-scales until they have shed a considerable portion of the pollen which they contain. The stigmata open somewhat after the ripening of the anthers, and do never stick out. Unlike this, the anthers of various forms of *Lutescens* protrude under certain con-

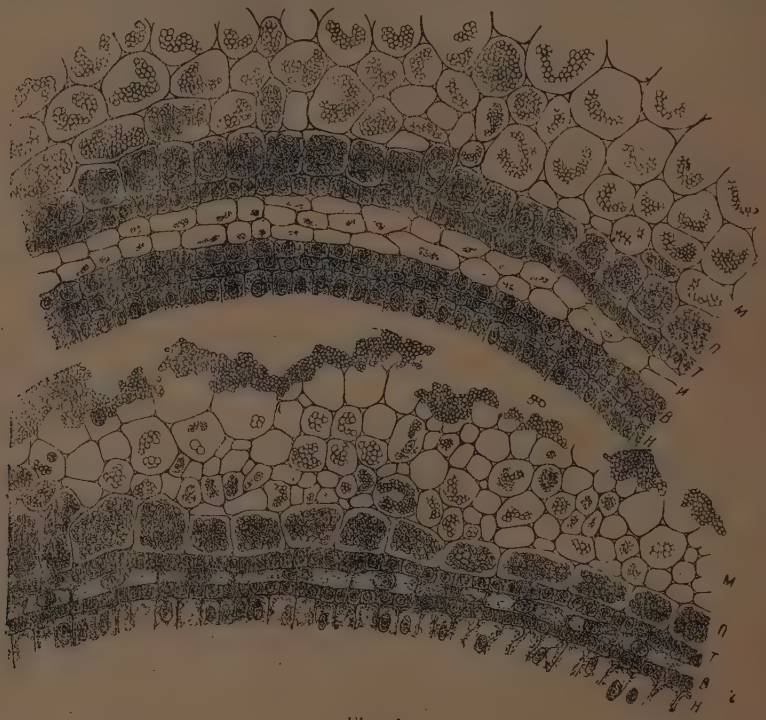

Fig. 1

ditions, even without bursting. Along with this the opened stigmata also protrude, sometimes rather strongly. The flowering of a spike in *Lutescens* lasts 2—3 days. The biology of flowering of the spelt entirely precludes any possibility of cross-pollination; it is a rigorously self-pollinating plant. In *Lutescens* cross-pollination is quite practicable; especially in northern regions where, for example, the variety *Lutescens* 062 (at Chibiny, outside the Polar circle) flowers after earing has been achieved.

A basic feature of the biology of flowering of cereals consists in that all of them are protandrous (proterandrous). This is an imperfect type of protandry, however, when the stigmata open and the female sexual apparatus is ready for fertilization before the active state of the anthers comes to an end. Various wheats differ as to the degree to which their protandry approaches to the perfect type. In our examples it is nearer to the perfect type in the spelt than in *Lutescens*. These differences

in the degree of perfection of protandry are found to be related with differences in the rate of disintegration or in the state of preservation of the external integument of the ovule during the formation of the kernel's spermoderm. Out of the fragmen-

Fig. 2

tary figures given here three illustrate the developmental stages of kernel integuments in spelt; from the stage of ovary up to that of wax ripeness. The fourth fragment shows the structure of the integuments in *Triticum lutinflatum* at the stage of wax ripeness. All of them represent areas of cross-sections of the dorsal side of a young fruit, of the very crest of the back within the middle part of the fruit.

Fragment 1 (Fig. 1), portion of a section of the ovary at the period of fertilization. The nucellus (H) is almost everywhere represented by the perisperm only. The inner integument (B) consists of two layers of cells filled with granular protoplasm and showing a well expressed cell nucleus. The same may be said of the inner epidermis of the ovary (T), from whose cells the tubular cells of the fruit (endocarp) are to be formed. The future transverse cells (П) are filled, alongside of a clearly distinct cell nucleus; with relatively coarse green plastids stuffed with fine starch grains. The state of the protoplasm of these cells is different from that in H, B and T: during the fixation of the material, there took place contraction of the cellular contents and its separation from the cell membrane. The external integument (И) already shows all the signs of an advanced disintegration: the cells contain scarcely any living substance, only cell membranes are left. But even in this state the external integuments have been preserved at the dorsal side only. When passing to the lateral and ventral part of the fertilized ovary, nothing more than a fibrous, entirely structureless mass is left behind.

At the stage of milk ripeness (Fig. 1, fragment 2) even at the dorsal side of a spelt-grain all traces of И vanish altogether. Changes that take place in H, B, T and П as well as in the mesophyll of the fruit (mesocarp, M), obey a certain regularity and are typical of wheat; they have been described for a number of examples (¹). At the stage of wax ripeness of the spelt (Fig. 2), along with corresponding

alterations in H (marked swelling of cell membranes) and in T, in B structural individuality of cells has been preserved solely in the inner layer, while the outer layer has the appearance of a structureless pellicle. At the stage of wax ripeness of *T. lutinflatum* (Fig. 3) the process of development of fruit-covers is much advanced as compared to the spelt (state of cell contents in all fruit-covers, its total disappearance except for П and cell coalescence of the mesocarp); the

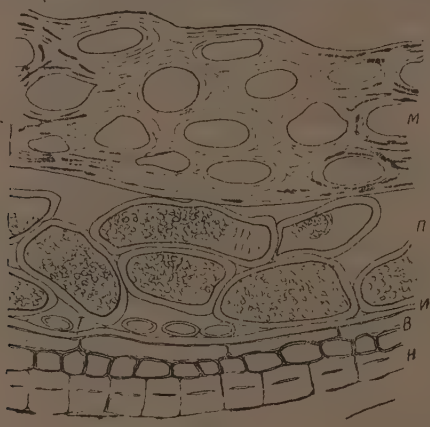

Fig. 3

two layers of B are not yet obliterated, and a clearly distinct pellicle has been preserved from И.

Thus, the external integument does not always disappear rapidly and without any trace. In rye, for example, И also remains quite distinct in the shape of a well-pronounced pellicle until the state of wax ripeness. Further on, towards the stage of full ripeness, there takes place its adhesion to the vestiges of B into a single common pellicle. Rye is a cross-pollinated plant in which both anthers and ovaries with stigmata develop almost at the same time (a well-pronounced imperfect type of protandry). *Lutescens* 062 which is cultivated at Chibiny, is remarkable for its thick spermoderm, И entering into its composition. In *Lutescens* 062 grown in southern regions, fertilization takes place at the period of earing, or somewhat prior to this period; in this variety protandry is closer to the perfect type and cross-pollination is out of question. The spermoderm of the kernel is accordingly thinner than in the kernels of plants grown in northern regions, and the participation of И in its composition is unnoticeable. Nielson-Oele who was the first to point out the participation of the remains of И in the formation of the spermoderm of a wheat kernel, had been working with late-ripening soft winter-wheat. Some of the winter wheats show a certain trend towards cross-pollination and, consequently, towards a sharply pronounced imperfect type of protandry.

What is then the relation between the degree of imperfection of protandry and the preservation of И vestiges in a kernel?

In its histogenesis the external integument is intimately linked both with T and with the so-called conducting tissue which pervades the upper part of the ovary wall and through which the pollen tube proceeds towards the cavity of the ovary. The lysogenous alterations that take place in the conducting tissue and in И seem to coincide and to be due to a similar cause, viz. to the influence of the pollen which having found its way on to the stigma develops there its life activity. From its very origination and till the end of dying-off all the parts of an ovary are engaged in a continuous flow of changes taking part in the life-cycle of the system—ovary-fruit; И and B thus become after a certain period covered with a cuticle which invests them from both surfaces. If the pollen happens to get on the

stigma early enough, before И has been covered with a cuticle; then И dissolves rapidly without any trace, being involved in the lysogenic process which prepares the way for the style. Such a picture may be observed in the spelt and, in general, in all wheats that approach to the perfect type of protandry. If however by the moment of pollination И has already formed a cuticle, then both its pellicles dissolve with great difficulty; moreover, the substance of the cellular membranes included between them, which was left behind after the obliteration of the cells of integument tissue, dissolves slowly, and may even remain undissolved at all, forming a more of less thin though distinct pellicle separating the pericarp from В. This is peculiar to wheats displaying a sharply pronounced imperfect type of protandry. The obliterated vestiges of the cells of И ; as well as both pellicles of the cuticle may, of course, in the subsequent course of ripening of the kernel undergo a lysogenic process under the influence of the enzymic action of another kind; however, the dissolution produced by the pollen activity ceases as soon as fertilization sets in.

Thus, the degree of preservation of the remains of an external integument in a wheat kernel is found to be intimately related with the peculiarities of the biology of flowering of a given plant. More attention should be given to the study of the peculiarities of pollination and of the degree of perfection of the type of protandry.

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ECOLOGY

DISTRIBUTION AND MODE OF FEEDING OF FIELD MOUSE *APODEMUS AGRARIUS* PALL. AND ITS BEARING ON EPIDEMICS

By P. A. SVIRIDENKO

(Communicated by L. A. Orbeli, Member of the Academy. 14.VII.1943)

The field mouse, *Apodemus agrarius* Pall., is an important vermin of agricultural and forest cultures; it is also a serious danger in respect of epidemies. In spite of this, our literature contains no studies devoted to the biology of *A. agrarius* Pall. (1).

Being spread in the middle belt of Western Europe; in China, Korea and Manchukuo, in this country the field mouse occupies the woodland (except the most

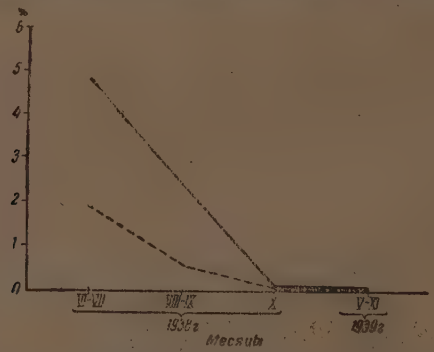

Fig. 1. Numerosity of the field mouse as affected by the drought of 1938 (in per cent of animals caught per 100 trap-days)
—— Plot with felt trees, — — — Young mixt wood

northern region) and the wood-steppe zone of the European part of this Union, partly in the Caucasus, South and Middle Urals, North Kazakhstan, Semirechie, the southern districts of Siberia (except Transbaikalia), and the southern districts of the Far-East region.

In the south-eastern steppe-regions of the Ukraine, in the Don, Near-Azov, Kalmuck and Cis-Caucasian steppes the field mouse is absent; more southerly it is common for the northern foothills and mountains of the Caucasus and the Black Sea littoral, from the town Novorossiysk to Gagry.

A similar discontinuity is observed in the area of distribution of the field mouse in the east: in East Siberia this species reaches lake Baikal, while in Transbaikalia it is absent to reappear in the southern part of the Far-East region.

The field mouse thrives under the conditions of the subtropical littoral of the Black Sea; at the same time, being cold-resistant as compared with some other *Murinae* (*M. arvalis* Pall., *M. minutus* Pall. and others), it ascends rather high in the mountains [11] (up to 1600 m), and occupies the southern districts up to almost 65° of northern latitude (Karelia)..

Apodemus agrarius Pall. belongs to the number of hydrophilous animals which poorly withstand conditions of air dryness. During the drought of 1938, according to observations carried on in the Tula department, the rodents occupied localities with higher humidity. Their propagation was depressed, and the population was rapidly decreasing (Fig. 1); in the autumn of the next year there was no *A. agrarius* at all in the region. This was mainly due to the drought of the summer, to the decrease in the annual amount of atmospheric precipitation which dropped to 365 mm, as compared to 559 mm, the annual mean for the Tula department.

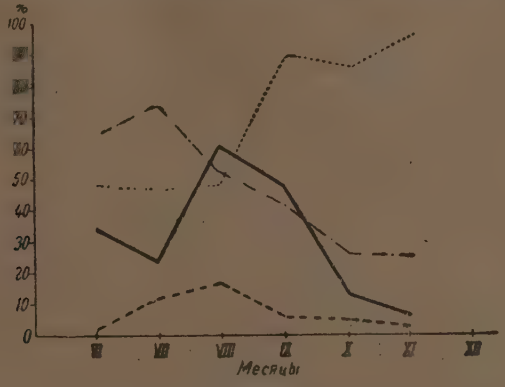

Fig. 2. Seasonal variation of food in per cent to the total number of animals examined

– – – Green parts, — — — Berries, ... Seeds, — · — · — Insects

When kept under conditions of excessive air dryness, the mice always show general depression and a sharp loss in weight.

Within the boundaries of its actual distribution area, the field mouse finds optimal life conditions in the most humid regions, where it usually appears in huge numbers.

Such regions are, in the first place, the southern part of the Far-East region and the Caucasus Black Sea littoral, where the total of mean annual precipitation amounts to 1000 mm and more. Next come the northern slopes of the Caucasus with about 700 mm per year. As to the frequency of mass invasions by the field mouse, these districts represent a «zone of stable reservation» [2] of the injurious activity of this rodent for agricultural and silvan cultures.

The second place as to the frequency of invasion by and numerousness of the field mouse corresponds to the woodland of the European part of this country, where the mean annual amount of atmospheric precipitation equals 500—700 mm. The harmful activity of the mouse is here of rather local character. This is the «zone of unstable reservation» of the field mouse.

Still less frequent is its appearance in the wood-steppes, where the precipitations are less than 500 mm per year, and especially in the steppe part of its distribution area. These districts compose the «zone of highly unstable reservation» of the field mouse, where the harmful activity of this species is the least important.

In steppe region with a mean quantity of annual precipitations equaling 350 mm and less the field mouse is of infrequent occurrence only along the banks of rivers and lakes, in overgrowths of reed and woody shrubs; under conditions of a humid microclimate.

The once continuous area of distribution of the field mouse was disunited during the glacial and post-glacial period. The direct causes that were operative here are: in Transbaikalia, the presence of a continuous ice-cover ([1],[2]), and in Cis-Caucasia, the broad water basin, Manych strait, uniting the Black and the Caspian Seas ([5],[7]). The semi-arid and arid landscapes that arose in those regions afterwards during the dry post-glacial period prevented the hygrophilous animal, and still prevent it from gaining its former continuous area of distribution.

The field mouse is rather pretenceless in the choice of its dwelling. Within the area of its distribution it inhabits various types of forests, gardens, shrub-thickets, open glades, and also ricks, stack, storehouses of eatables, various out-houses and even inhabitable dwellings.

The field mouse is a decidedly eurytopic animal. In more humid regions; however, it chooses for settling the most various biotopes, while in regions with insufficient humidity the diversity of its abodes is somewhat restricted. But even allowance being made for those restrictions, the species remains eurytopic, though in the latter case its being eurytopic is manifest only in a choice of a sufficiently humid habitation medium.

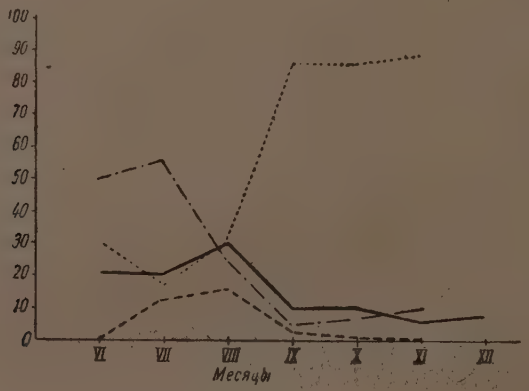

Fig. 3. Seasonal prevalence of food (in per cent of animals in whose stomachs a given food was found to prevail)

——— Green parts, — — — Berries, ····· Seeds, — · — · — Insects

By the mode of feeding the field mouse stands apart from the rest of mouse-like rodents ([6]). It is euryphagous, and, along with seeds, berries, roots and green parts of various cultured and wild plants, it feeds also on insects. In the diet of the field mouse seasonal variations may be observed: it is especially rich in insects during summer and autumn, although seeds are also available in abundance during this season (Figs. 2 and 3).

Being a poor digger, the field mouse contents itself with a burrow not very deep and of simple arrangement ([4]). Unlike many other mouse-like rodents, it does not store food in the burrow; or near it. This feature of its behaviour is rather one of a rapacious animal which devores its food at the very place of capture, being more mobile than an animal confined to vegetable food. The euryphagous

mode of feeding accounts for the eurytopic distribution of the field mouse in the regions where it is spread.

It is natural that being eurytopic and of considerable mobility the field mouse enters into contact with other animals inhabiting the same stages, more frequently than the rest of rodents. This makes the field mouse more liable to all kind of contagious diseases putting the species as a whole in unfavourable conditions in the biocoenosis. However, the field mouse proved little susceptible to many infectious diseases (e. g. those transmitted by mouse and rat bacteria of the paratyphoid group, *B.* Danysz, *B. typhi murium*; *B. Spermophilorum*, *B. tularense*), and utterly unsusceptible to encephalitis.

In connexion with its eurytopic habit, mode of feeding and increased mobility, this species developed in the course of its evolution a new adaptive character: a reduced susceptibility to infection with diseases common to other rodent species.

Owing to these biological features, the field mouse occupies in the development and spreading of various infectious diseases among animals and men a place of its own, which is unlike to that of the rest of rodents.

Thus, in the experiments involving infection of the field mouse with encephalitis, this rodent was found to be a symptomless virus carrier, in which there takes place no concentration of the virus (²). This testifies to a minor epidemiological importance of the field mouse as a direct virus vector.

However, the field mouse is often infested by parasites which are the basic transmitters of encephalitis, viz. *Ixodes persulcatus* and *Ixodes ricinus*. In the organism of these ticks the virus undergoes intense propagation, accumulating gradually and being kept for a long time without causing lethal effect.

Being resistant to the disease, a field mouse infested by encephalitis ticks may thus serve as a source of infection during a much longer period of time than other rodents that perish of encephalitis.

The field mouse uses to inhabit the same places as the water-rat which in this country acts as the main transmitter of tularaemia. It is likely therefore to be the most important link in the course of tularaemic epizootics: from water biotopes occupied by the rat the infection is likely to be transmitted through parasites to ricks of grain and straw, inhabited buildings and their belongings, infecting there the house-mice, other animals, and also men.

Because of its eurytopic habit and mobility, the field mouse favourably compares with stenotopic species with regard to its interspecific and specific contact with rodents occupying different biotopes. And this is the cause of the great epidemiological importance of this rodent.

The ecological peculiarities of the field mouse brought out by us give some ground to prognosticate its further migration, as well as its mass invasions inflicting great losses to agricultural crops and forestry.

Conditions prevailing in the steppes and mountainous regions with insufficient moisture which cover the south-eastern part of the USSR and Transbaikalia present an obstacle for the further migration of the hygrophilous rodent. However, along river valleys and irrigation systems the field mouse may occasionally find all that is necessary for its subsistence. It is therefore necessary to take in advance all possible measures to prevent the field mouse from penetrating into those regions.

In warm regions with excessive moisture where the field mouse finds optimal conditions for its thriving, frequent outbreaks of its mass propagation should be anticipated; here adequate measures are to be applied systematically in order to control the pest.

In the wood-steppe zone where the field mouse has no continuous distribution occupying mostly humid biotopes, its mass invasions may be anticipated over a more or less wide area at years with increased atmospheric precipitations. At periods of drought this species will experience a depressive state.

At more northern and cold regions with increased moisture the field mouse is likely to appear in great numbers at years with a warmer summer season.

It stands to reason that in order to propagate in huge masses the field mouse requires, aside from favourable climatic conditions, also appropriate food in sufficient quantity.

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